RCRA CORRECTIVE MEASURES STUDY

NGK METALS CORPORATION READING FACILITY

Prepared for:

NGK Metals Corporation
Reading Facility
Reading, Pennsylvania 19612

March 13, 1992
Revised: May 8, 1992

DUNN

DUNN CORPORATION

Engineers, Geologists, Environmental Scientists
2 Market Plaza Way
Mechanicsburg, Pennsylvania 17055
Tel: 717/795-8001
Fax: 717/795-8280

RCRA CORRECTIVE MEASURES STUDY

NGK METALS CORPORATION READING FACILITY

Prepared for:

NGK METALS CORPORATION
READING FACILITY
READING, PENNSYLVANIA 19612

Prepared by:

DUNN CORPORATION
2 MARKET PLAZA WAY
MECHANICSBURG, PENNSYLVANIA 17055

Date:

MARCH 13, 1992
REVISED: MAY 8, 1992

TABLE OF CONTENTS

	PAGE
LIST OF FIGURES	v
LIST OF TABLES	v
EXECUTIVE SUMMARY	vi
1.0 PURPOSE	1-1
1.1 Site History	1-1
1.1.1 Ownership History	1-1
1.1.2 Manufacturing History	1-2
1.1.3 Waste Management History	1-4
1.2 Regulatory Status	1-4
1.2.1 Air	1-4
1.2.2 Water	1-4
1.2.3 Solid Waste	1-6
1.3 Facility Setting	1-7
1.3.1 Physiographic	1-7
1.3.2 Surrounding Land Uses	1-7
1.3.3 Site Topography	1-7
1.3.4 Site Surface Drainage	1-7
1.3.5 Site Geology	1-8
1.3.6 Site Hydrogeology	1-9
1.4 Description of Solid Waste Management Units (SWMU)	1-9
1.4.1 Pond 1	1-9
1.4.2 Pond 2	1-11
1.4.3 Pond 3	1-11
1.4.4 Southeast Red Mud and Filter Cake Disposal Area	1-11
1.4.5 Southwest Red Mud and Lime Disposal Area	1-12
1.4.6 Retention Basin	1-12
1.4.7 Soil Stock Pile Near Former Pond 6	1-12
1.4.8 Drain Field Area	1-13
1.5 Summary of RFI and HHE Findings	1-13
1.5.1 Mechanism for Release	1-13
1.5.2 Nature of Release	1-15
2.0 OBJECTIVE OF THE CORRECTIVE MEASURES STUDY	2-1
2.1 Identification of Potential Technologies	2-1
3.0 CRITERIA USED IN THE EVALUATION OF TECHNOLOGIES	3-1
3.1 Evaluation Process	3-1
3.2 Effectiveness	3-1
3.2.1 Anticipated Short-Term Effectiveness	3-1
3.2.2 Anticipated Short-Term Effectiveness and Performance	3-2
3.3 Reliability - The Reduction of Toxicity, Mobility and/or Volume	3-2
3.4 Implementability	3-2
3.5 Costs	3-3
3.6 Overall Protection of Human Health and the Environment	3-4

TABLE OF CONTENTS (CONTINUED)

PAGE

4.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES - AFFECTED SOILS AND WASTE MATERIALS 4-1
- 4.1 Surface Water Controls 4-1
  - 4.1.1 Control of Water Running into the Site 4-1
  - 4.1.2 Improving Surface Drainage 4-1
- 4.2 In-Situ Isolation Technologies 4-2
  - 4.2.1 Capping 4-2
  - 4.2.2 Slurry Walls 4-3
- 4.3 In-Situ Treatment of Waste Materials/Soils 4-3
  - 4.3.1 Solidification/Stabilization 4-3
  - 4.3.2 Vitrification 4-8
- 4.4 Excavation of Buried Wastes 4-8
- 4.5 Ex-Situ Treatment of Wastes on Site 4-8
  - 4.5.1 Stabilization/Solidification 4-8
- 4.6 On-Site Landfilling 4-9
- 4.7 Off-Site Disposal 4-12
- 4.8 Off-Site Treatment and Disposal 4-12
  - 4.8.1 Solidification/Stabilization 4-12
  - 4.8.2 Low Temperature Thermal Processing 4-12

5.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES - AFFECTED GROUNDWATER 5-1
- 5.1 Recovery and Control of Affected Groundwater 5-1
  - 5.1.1 Extraction Wells 5-1
  - 5.1.2 Interceptor Trenches 5-2
  - 5.1.3 Physical Barriers 5-2
- 5.2 Treatment of Affected Groundwater 5-3
  - 5.2.1 Organic Compounds 5-3
  - 5.2.2 Inorganic Ions with Potential Production Interferences 5-3
  - 5.2.3 Inorganic Metals 5-4
- 5.3 Management of Treated Groundwater 5-4

6.0 EVALUATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES 6-1

7.0 JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S) 7-1
- 7.1 Description of Selected Corrective Measures 7-1
- 7.2 Basis for Selection 7-5
  - 7.2.1 Technical 7-5
    - 7.2.1.1 Effectiveness 7-5
    - 7.2.1.2 Reliability 7-6
    - 7.2.1.3 Implementability 7-7
    - 7.2.1.4 Safety 7-7

LIST OF FIGURES

1-1	Site Location Map	1-3
1-2	NESHAP Ambient Air Sampler Location Map	1-5
1-3	Solid Waste Management Unit (SWMU) Location Map	1-10
4-1	RCRA Multi-Layer Cap	4-4
4-2	Modified Pennsylvania Multi-Layer Cap	4-5
4-3	Asphalt Cap	4-6
4-4	Concrete Cap	4-7
4-5	RCRA Landfill Liner Crosss Section	4-10
4-6	RCRA Landfill Liner Detail	4-11
5-1	Preliminary Treatment Schematic	5-5
7-1	RCRA Corrective Action Implementation Schedule	7-2
7-2	Extraction Well Locations	7-3

LIST OF TABLES

1-1	Levels of Site Specific Chemicals Detected in Various Environmental Media	1-14

EXECUTIVE SUMMARY

The purpose of this NGK Metals Corporation RCRA Corrective Measures Study (CMS) report is to summarize the process used to develop and evaluate remedial action alternatives and to present a recommendation to mitigate potential public health and environmental impacts associated with historical waste disposal practices at the site presently owned by NGK Metals Corporation (NGK). The CMS was completed in response to a RCRA 3008(h) Corrective Action Order (PAD 04 454 0136) issued by the U.S. Environmental Protection Agency (EPA). The CMS was performed so that an alternative or alternatives consistent with the goals of the EPA and the Pennsylvania Department of Environmental Resources (PaDER) could be selected.

In accordance with the National Contingency Plan (NCP), an appropriate extent of a remedy is defined as a "cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment" [40 CFR 300.68 (i)]. This CMS is based upon information and data presented in the NGK RCRA Facility Investigation (RFI) as amended in October 1991 and the Human Health Evaluation and Ecological Assessment (HHE) dated January 1992.

Based upon the results of the RFI and HHE it appears that historical waste management practices at the NGK facility may have resulted in releases of waste constituents to the environment. Corrective action may be required to insure that the environment and human health are protected.

In this report, technologies which may have application in the development of a comprehensive corrective action program are described, and evaluated for use at the facility. The technologies which passed an initial evaluation were used to develop corrective action strategies which were evaluated in detail and from which an appropriate corrective action program was selected.

The methodology used in this CMS report allows a step-by-step evaluation of technologies, alternatives and assembled alternatives by progressing through a series of screenings and evaluations. Initially, general qualitative information was used. Subsequently, more refined and quantitative information was used to eliminate infeasible or otherwise unacceptable actions from consideration. This methodology provides a systematic procedure for identifying and evaluating alternatives and developing recommendations.

The affected areas, fully described in section 1.4, consist of previously used settling ponds, a retention basin, a drain field, a soil stockpile ,and a filter cake and lime sludge disposal areas.

The combination of corrective measures selected to best meet the first phase environmental needs of the NGK site follows:

(1) Maintain the existing fence which encloses the entire facility to enclose the affected area and prevent unauthorized entry. A 24 hour per day security force is employed to prevent unauthorized entry;

(2) Build an interceptor swale around the following locations to prevent storm water run-on onto the affected areas:
- Pond 2;
- Pond 3;
- Southeast Red Mud & Filter Cake Disposal Area; and
- Southwest Red Mud & Lime Sludge Disposal Area;

(3) Address the SWMU's at the site as follows:

Retention Basin - NGK's office parking lot is in-place over this former disposal area. This parking lot is a well maintained macadam surface area with storm sewers in place to divert storm water run-off. Modelling demonstrates that no further action is required at this location;

Pond #1 - Cap this area with an impermeable asphalt - geotechnical membrane cap to prevent the intrusion of precipitation through the affected soils and wastes which will be left in place and undisturbed;

Pond #2, The Southeast Red Mud & Filter Cake Disposal Area, And The Southwest Red Mud & Lime Sludge Disposal Area (Red Mud Area) - Cap these areas with a single impermeable asphalt - geotechnical membrane cap to prevent the intrusion of precipitation through the affected soils and wastes which will be left in place and undisturbed;

Pond #6 Waste Pile - Relocate this soil / waste pile to the Red Mud Area and use it to help develop a 2% slope beneath the cover to promote run-off in that area; and

Disposal Area Drain Field - No waste materials were disposed in this area. However, surface contamination exists in this area as a result of surface water run-off from the above disposal areas. Modelling demonstrates that an impervious cap is not required for this area. Cover this area with 6 to 12 inches of clean soil such as loam and vegetate the area to prevent wind dispersion and direct contact with contaminated soils;

(4) Analytical monitoring will be employed to track the progress of the control measures of Phase 1 and help determine how the technologies will be implemented in Phase 2.

The combination of corrective measures selected to best meet the second phase environmental needs of the NGK site follows:

(1) Evaluate the impact of Phase 1 activities on groundwater movement and groundwater quality at the NGK site.

(2) Install extraction wells to help control local groundwater table elevations to restrict the movement of affected groundwater off-site.

(3) Pump the recovered water to an on-site treatment facility where it can be processed to remove the materials which make it inappropriate for use within the production facility or for discharge to the environment;

(4) Use or manage the treated groundwater in an appropriate and environmentally acceptable manner. Environmental operating permits appropriate to the selected method of managing the groundwater will be secured prior to discharge.

Further leaching of the water soluble and organic contaminants contained in the wastes will be prevented. Eventually, as the groundwater is withdrawn and treated, the aquifer will be flushed with unaffected water and be restored. The process of restoration of the groundwater will probably be long-term.

Basis for Selection

The selected combination of corrective measures is being recommended on the basis of an optimization of the integrated factors of anticipated effectiveness, reliability, implementability, protection and cost-effectiveness associated with the combination.

Each potential combination was first examined with respect to human and environmental protection. If it was apparent that human or environmental protection would or could be unacceptably compromised by the selection of a site corrective measures system it was eliminated from consideration. Three major areas of human or environmental protection concern were considered: (1) Groundwater, (2) Waste/Soils, and (3) Construction/Transportation.

Those combinations which passed the initial human and environmental safety screening were then examined with respect to the other enumerated factors, with effectiveness on the NGK site being a key screening factor. Obviously, in addition to being effective, the selected combination also had to be reliable, implementable and cost effective.

Effectiveness

Effectiveness is defined as the ability of the properly implemented technologies to meet the stated objectives of the corrective action program. The effectiveness of the selected combination of corrective measures is expected to be excellent:

(1) Human contact with the wastes/soils will be minimized by maintaining the fencing surrounding the affected area and by installing an impermeable cap.

(2) The potential for dispersion of airborne metals will be minimized by allowing the wastes in the disposal areas to remain undisturbed prior to capping.

(3) Interceptor swales will prevent the run-on of stormwater and its subsequent percolation through the waste disposal areas.

(4) Extraction wells will help control local groundwater table elevations to restrict the movement of affected groundwater off-site.

(5) The groundwater will be treated to an appropriate level to allow its reuse or discharge to the environment.

Reliability

Reliability is defined as the ability of the properly implemented technologies to control and minimize the toxicity, mobility, and volume of the wastes and affected soils and groundwater. The reliability of the selected combination of corrective measures is expected to be excellent:

(1) The asphalt geotechnical cap will reduce the mobility of the contaminants present in the wastes and the soil by preventing the intrusion of and attendant leaching by precipitation;

(2) The asphalt geotechnical cap will prevent the dispersion (mobility) of airborne metals by wind erosion;

(3) The interceptor swales will reduce the mobility of the contaminants present in the wastes/soils by reducing the amount of surface water run-on available for percolation through to the groundwater;

(4) The extraction wells control the mobility of affected groundwater at the facility

(5) The technologies which will be employed to treat the affected groundwater will control and minimize its toxicity. The materials

which are removed from the groundwater through treatment will be handled as solids and disposed of in permitted facilities. They will be managed so that they do not reenter the environment;

(6) The total volume of materials, including water considered as waste, which must be handled as waste will decrease as a result of the concentrating effects of the treatment process.

(7) The series of processes by which the groundwater is treated allows the observation of progress in the restoration of groundwater. Analytical procedures appropriate to the detection and quantification of the contaminants of interest are available. When the contaminant level stabilizes and remains stable for eight successive sampling periods, the remediation process will conclude. Stability is defined as the point at which the values of eight successive quarterly analyses for Be, Cd, Cr and Cu, 1,1 DCE and TCE fall within + or - 20% of the average of the four values.

Implementability

Implementability is defined as an assessment of the feasibility and ease with which the selected combination of technologies can be employed at the NGK facility. It is expected that the implementability will be excellent:

(1) There is adequate room at the NGK facility to install and operate the technologies;

(2) The technologies are compatible with the surrounding areas and will not have an adverse impact upon them;

(3) The technologies will not adversely impact plant operations;

(4) The selected combination of technologies minimizes the number and variety of permits required to accomplish the stated objectives of the corrective action program;

(5) The resources to implement the selected technologies are readily available to NGK;

(6) Experienced, qualified contractors are available within reasonable distance of the site to assure competitive bids; and

(7) The technologies will have minimum impact upon the future beneficial use and control of the NGK facility.

Protection (of human health and the environment)

Protection is defined as the minimization or elimination of dangers to human or environmental health. It is expected that the protective capacity of the proposed combination of technologies will be excellent:

(1) Other than those associated with construction related activities, there are no known human or environmental protection issues related to the construction of the interceptor swales, or the construction of the impermeable cap;

(2) The exposure of humans (on-site or off-site) or the environment to wastes or affected soils and groundwater will be minimized through the use of the selected technologies.

1.0 PURPOSE

The purpose of this NGK Metals Corporation RCRA Corrective Measures Study (CMS) report is to summarize the process used to develop and evaluate remedial action alternatives and to present a recommendation to mitigate potential public health and environmental impacts associated with historical waste disposal practices at the site presently owned by NGK Metals Corporation (NGK). The CMS was completed in response to a RCRA 3008(h) Corrective Action Order (PAD 04 454 0136) issued by the U.S. Environmental Protection Agency (EPA). The CMS was performed so that an alternative or alternatives consistent with the goals of the EPA and the Pennsylvania Department of Environmental Resources (PaDER) could be selected.

In accordance with the National Contingency Plan (NCP), an appropriate extent of a remedy is defined as a "cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment" [40 CFR 300.68(i)]. This CMS is based on information and data presented in the NGK RCRA Facility Investigation (RFI) as amended in October 1991 and the Human Health Evaluation and Ecological Assessment (HHE) dated February, 1992.

Based on the results of the RFI and HHE, it appears that historical waste management practices at the NGK facility may have resulted in releases of waste constituents to the environment which may require corrective action to insure that the environment and human health are protected.

In this report, technologies which may have application in the development of a comprehensive corrective action program are described, and evaluated for use at the facility. The technologies which pass an initial evaluation will be used to develop corrective action strategies which will be evaluated in detail and from which an appropriate-corrective action program will be selected. The methodology used in this CMS report allows a step-by-step evaluation of technologies, alternatives and assembled alternatives by progressing through a series of screenings and evaluations. Initially, general qualitative information is used. Subsequently, more refined and quantitative information is used to eliminate from consideration infeasible or otherwise unacceptable actions. This methodology provides a systematic procedure for identifying and evaluating alternatives and developing recommendations.

1.1 Site History

1.1.1 Ownership History

In October, 1986, NGK Metals Corporation purchased the beryllium alloy manufacturing facility located in Muhlenberg Township, Berks County, Pennsylvania. The manufacturing facility is situated on an approximate 65 acre parcel of land located about four (4) miles north of downtown Reading. The facility is bounded on the north by Tuckerton Road, on the east by Conrail railroad tracks, on the south by Water Street,

and on the west by commercial and residential buildings. The exact location of the NGK facility is shown on Figure 1.1 - Site Location Map.

Industrial activities at this location date back prior to November 1935 when the site was owned and operated by the Pennsylvania Malleable Iron Company. In November of 1935, the site was purchased by the Beryllium Corporation. In March of the following year, through its subsidiary, the Beryllium Corporation of Pennsylvania, the Beryllium Corporation began manufacturing operations at the site. In October 1968, the Beryllium Corporation merged with the Kawecki Chemical Corporation to form Kawecki Berylco Industries, Inc. (KBI). In May of 1978, KBI became a wholly owned subsidiary of Cabot Corporation (Cabot) when Cabot purchased all outstanding common shares of KBI stock. In October 1982, the former KBI was merged into Cabot Corporation.

On September 30, 1986 Cabot sold the assets of the Reading beryllium alloy plant to NGK Metals Corporation, a wholly owned subsidiary of NGK Insulators Ltd. The plant continues to operate today as NGK Metals Corporation (NGK).

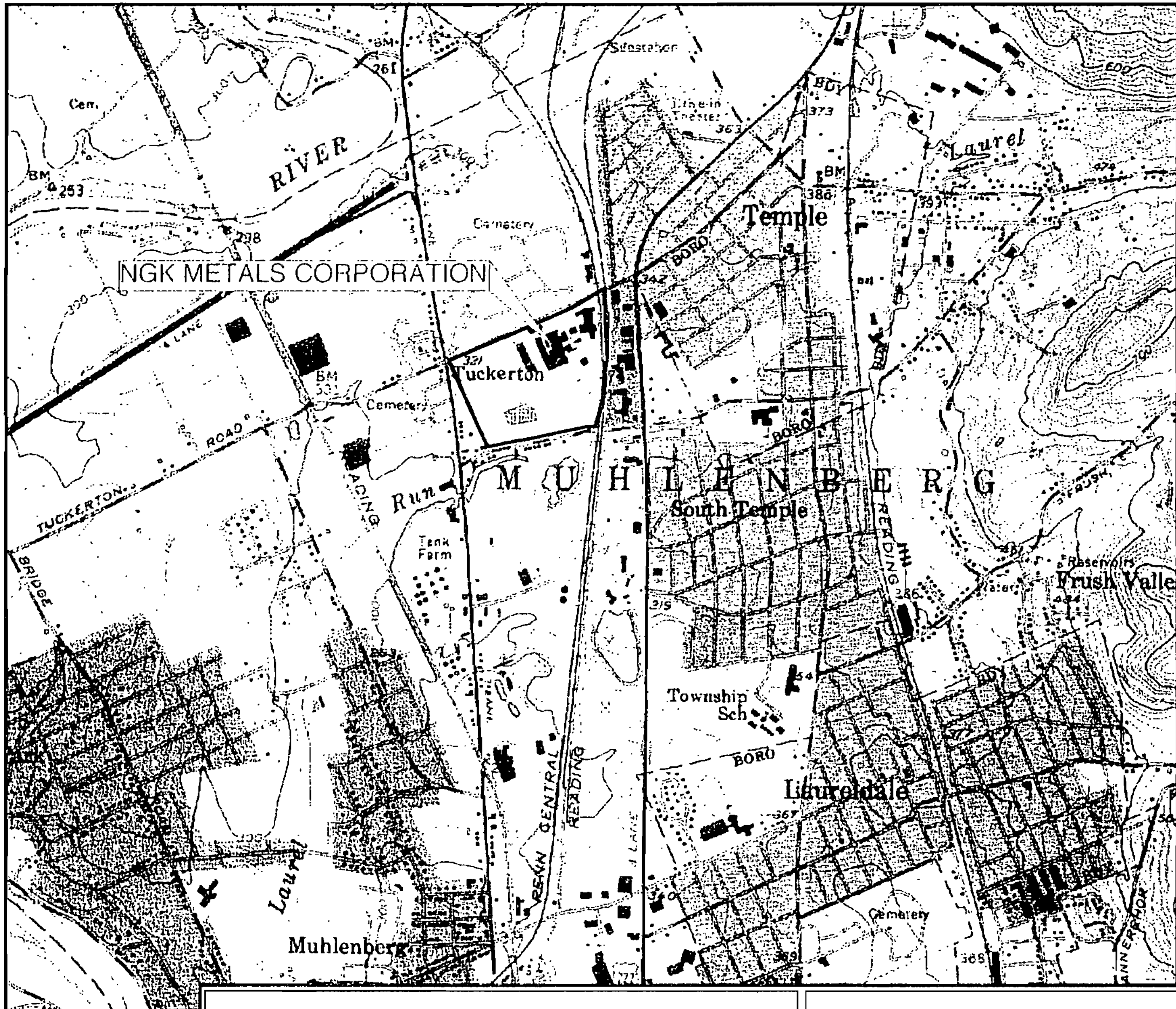
1.1.2 Manufacturing History

There is no information available on manufacturing activities at the Reading plant site when it was operated prior to 1935 by the Pennsylvania Malleable Iron Company. In March of 1936 the Beryllium Corporation started the manufacture of beryllium products at the Reading plant. From 1936 through 1965, production activities at the site included:

- Extraction of beryllium hydroxide from beryl ore.
- Production of beryllium salts.
- Production of various shapes of beryllium metals and alloys.

In 1965 the extraction of beryllium hydroxide from ore ceased and the operations at the facility were limited to:

- Calcining beryllium hydroxide.
- Production of beryllium alloys with copper, nickel and aluminum.
- Casting of beryllium alloys.
- Rolling (hot and cold) beryllium alloys.
- Heat treatment of beryllium alloys.
- Chemical and mechanical cleaning of beryllium alloys.



NOTE: Base map taken from Temple, PA USGS 7.5 minute quadrangle

DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

SITE LOCATION MAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: February 1992	SCALE: 1"=2000' APPROXIMATE	FIGURE NO.: 1-1

1.1.3 Waste Management History

Since the mid-1930's this site was used to manufacture beryllium containing products. Wastes resulting from the extraction, manufacture, and processing of beryllium related products were managed on-site from the mid-1930s until the early to mid 1960s. Wastes disposed at the facility include ore and gangue, the residual solid waste from the extraction of beryllium from beryl ore. Also retained on site were wastes sludges resulting from the use of lime to treat and neutralize waste waters resulting from the manufacturing operations. Based on groundwater quality data, it appears that some organic solvents have also been released at the facility. Additional detail regarding waste management practices is presented in Section 1.4.

NGK currently uses a two acre landfill constructed on the facility in the early 1980s for the management of residual non-hazardous beryllium containing materials from its current operations. This landfill is permitted by the Pennsylvania Department of Environmental Resources (PaDER).

1.2 Regulatory status

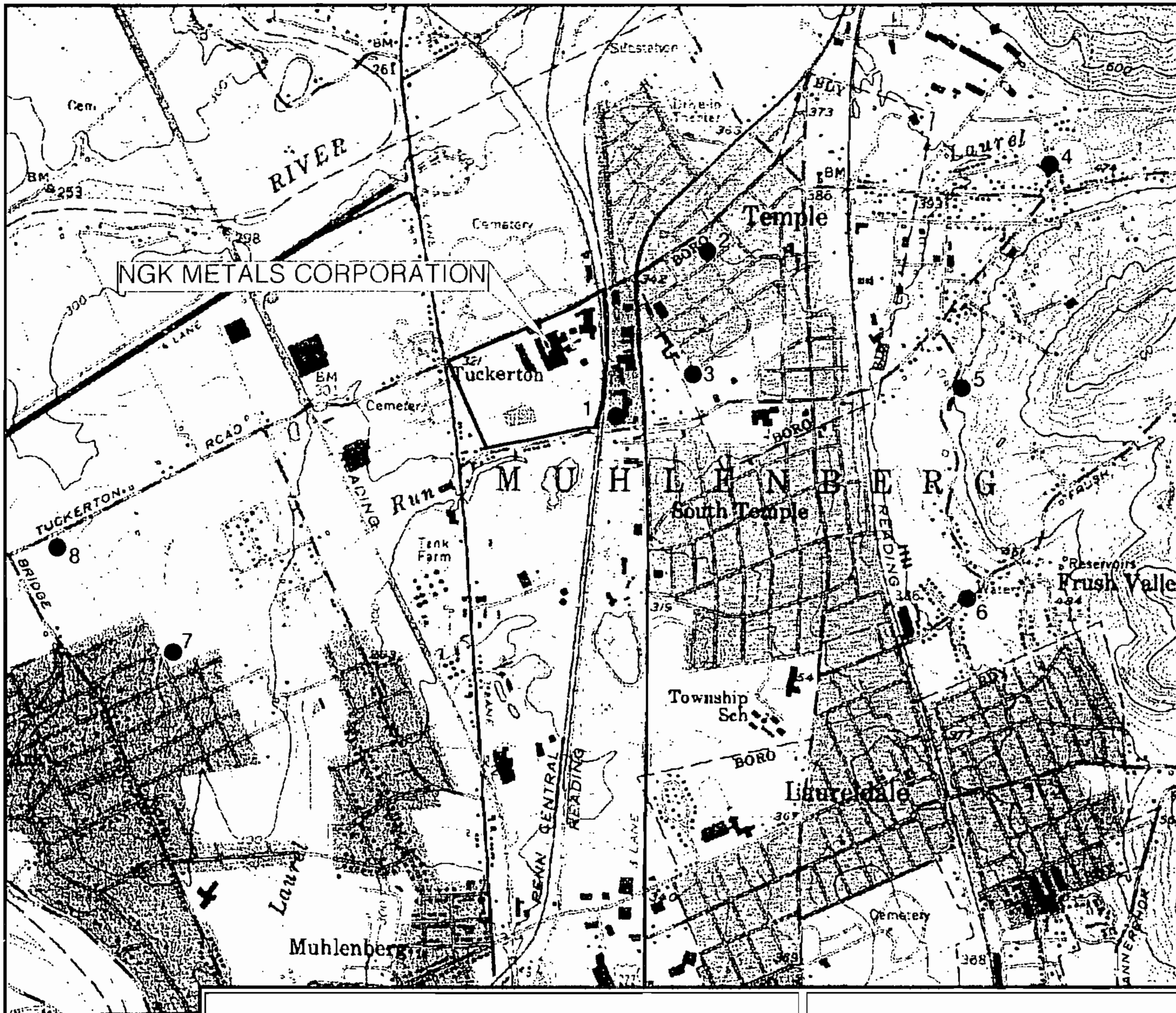
1.2.1 Air

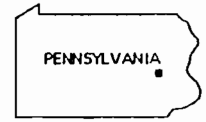
Air emissions form the NGK facility are regulated under EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP). In Pennsylvania, the NESHAP program is administered by PaDER. Since the facility owned by NGK predates the promulgation of the NESHAP standard for beryllium, the facility meets a community ambient air beryllium standard rather than a stack emission standard. Under this program, NGK constantly (24 hours per day) monitors air quality using an EPA approved sampling network consisting of eight sampling locations strategically located throughout Muhlenberg Township and Temple Borough. These sampling stations are shown on Figure 1.2 - NESHAP Ambient Air Sampler Location Map.

1.2.2 Water

Waste waters generated at the NGK facility can be classified into four major categories: sanitary wastes; cooling waters; industrial waste water; and landfill leachate. All sanitary waste waters are discharged to the City of Reading's waste water treatment facility via the Muhlenberg Township Authority's sanitary sewer collection system. A limited quantity of waste water generated from industrial processes such as alkaline cleaning of wire is also discharged to the sanitary sewers. The City of Reading has therefore issued NGK a permit authorizing these discharges.

Landfill leachate is generated on an infrequent basis. The leachate is collected and is treated using lime neutralization and sedimentation technology. The treated leachate is monitored and discharged to the sanitary sewers under authority of a permit issued by the City of Reading.





NOTE: Base map taken from Temple, PA USGS 7.5 minute quadrangle

LEGEND

6 ● AMBIENT AIR STATION NUMBER

DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

NESHAP AMBIENT AIR SAMPLER LOCATION MAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: February 1992	SCALE: 1"=2000' APPROXIMATE	FIGURE NO.: 1-2

NGK generates both contact and non-contact cooling waters which are discharged to treatment facility prior to partial recirculation and ultimate discharge to the Laurel Run Stream. Treatment of contact and non-contact cooling waters consists of spray cooling, oil removal, sand filtration for solids removal and effluent monitoring. The operation of this facility and the effluent discharge is permitted by PaDER.

NGK generates process waste waters as a result of the mechanical and chemical cleaning of beryllium alloys. These waste waters are collected and treated at an on-site waste water treatment plant. This treatment plant consists of the following process steps:

- Equalization
- Neutralization
- Flocculation
- Sedimentation
- Flocculation
- Filtration
- Final pH Adjustment
- Sludge Dewatering

After treatment, the treated effluent is monitored to ensure compliance with treatment specifications. If the treated water is outside of specification, it is automatically returned to the front end of the treatment plant for reprocessing.

Treated waste water treatment effluent and cooling pond effluent are combined, continuously monitored and discharged to the Laurel Run. This discharge is authorized under PaDER National Pollution Discharge Elimination System (NPDES) Permit # PA0011363.

1.2.3 Solid Waste

Both residual and RCRA hazardous wastes are currently generated by NGK. With the exception of wastewater, all hazardous wastes generated by NGK (such as spent acids) are transported off-site for recovery, treatment and/or disposal as appropriate.

Residual wastes for which recovery techniques do not exist are disposed of either on-site or off-site as appropriate. NGK currently uses a two acre landfill constructed on the facility in the early 1980s for the management of residual non-hazardous beryllium containing wastes from its current operations. The landfill was installed with the philosophy that beryllium would be recovered from materials in the landfill if and when future technologies are developed to allow this to occur. This landfill is permitted by the Pennsylvania Department of Environmental Resources (PaDER). All non-beryllium containing residual wastes are taken off-site for recovery or disposal.

1.3 Facility Setting

1.3.1 Physiographic

The NGK facility is situated approximately four (4) miles north of center city Reading in Muhlenberg Township, Berks County, Pennsylvania. The approximately 65 acre site is bounded by Tuckerton Road, Water Street, Conrail and Pennsylvania Route 61 (Pottsville Pike) to the north, south, east and west, respectively.

1.3.2 Surrounding Land Uses

Muhlenberg Township is characterized by a combination of industrial, commercial, residential, and agricultural development. The approximate breakdown of land use is as follows:

- Industrial 30-35%
- Residential 25-30%
- Commercial 25%
- Agricultural 15%

1.3.3 Site Topography

The plant complex rests on near flat terrain, which gently slopes towards the south-southwest, ultimately reaching the floodplain of Laurel Run. Laurel Run flows southwest approximately two (2) miles southwest of the site to its confluence with the Schuylkill River, which discharges to the south and acts as the primary drainage pathway for the valley. The area of investigation is situated regionally within the Lower Delaware River Basin and locally, the Schuylkill River subbasin.

Topographically, the site elevation ranges from less than 302 feet to about 328 feet above mean sea level (msl), and has minimal slopes of 0-8%. Despite extensive regrading of the land surface for excavation and construction purposes, it is believed that the general slope conditions have remained relatively unchanged.

1.3.4 Site Surface Drainage

The site is located in a part of the Schuylkill River valley which regionally consists of low rounded hills undulating to flat lowland and floodplain topography. Locally, the karst derived landforms exist due to the dissolution of the underlying carbonate rock (i.e., limestones and dolomites). Karst terrain is characterized by closed depressions or sinkholes, caves. The drainage patterns in the region, which are dendritic, are influenced

by the structural characteristics of the underlying carbonate bedrock. There is little evidence of surface drainage on-site, which is typical of carbonate terrain. On-site, surface water drains west and south. To the west is a large depression at the corner of Tuckerton Road and PA Route 61. Standing water commonly occurs here. Drainage to the south approaches Laurel Run.

A previously existing sinkhole developed (circa late 1950s) in the north-central portion of the site just east of well MW-17A, but has since been filled in with soil material. The closed depression near the intersection of PA Route 61 and Tuckerton Road may be a surface expression of a sinkhole. Additionally, a sinkhole located in the Laureldale Cemetery directly across Tuckerton Road from the NGK administration building appears on several dated aerial photographs. It has since been filled in with soil excavated from the cemetery.

1.3.5 Site Geology

The NGK site lies near the eastern edge of a distinctive physiographic province known as the Great Valley, which extends from New Jersey to Alabama. This area consists mainly of complexly folded and trust-faulted carbonate rock of Cambrian to Middle Ordovician age. Hills of Precambrian gneiss and Lower Cambrian quartzite flank the valleys and forms part of the Reading Prong of the New England physiographic province, which lies to the east of the study area.

The site is located on the western flank of a faulted, recumbent anticline or arched structure. Site-specific stratigraphic formations belong to the Lehigh Valley Sequence and, more precisely, the Leithsville and Allentown Formations. Further, the Allentown is comprised of the Maiden Creek, Muhlenberg and Tuckerton Members of the Upper Cambrian age.

Immediately underlying the NGK site is the Tuckerton Member of the Allentown Formation, a cyclic sequence of solution-prone carbonate bedrock units consisting of primarily medium to dark gray dolomite and dolomitized limestones which have been extensively faulted and folded. This is evident by the development of fractured bedrock and solution features at and below ground level. Although rock outcrops are relatively infrequent, one is noted on-site in the northwest corner of the property.

A geologic contact between the Tuckerton Member, which is the oldest and therefore lowest stratigraphic member of the Allentown Formation, and the younger Muhlenberg member has been mapped near the southern edge of the site. This contact virtually parallels Water Street along the southern border of the site.

Fracture trace analysis indicates the presence of a dominant north-northeast trending fracture set, and a minor south-southeast trending set (Figure 4-4). Fracture traces identified on-site appear primarily in the southwest part of the site. Possible northward extensions of these traces across the site are obscured due to interference from existing plant buildings and associated regrading of the land surface.

1.3.6 Site Hydrogeology

Regionally, the site is located within the Delaware River Basin, and locally within the Schuylkill River subbasin. Laurel Run, a tributary to the Schuylkill River, is just to the south of the site across Water Street.

Groundwater flow within the Allentown and Leithsville Formations is controlled by secondary porosity along bedding planes, joints, fractures and solution channels. Generally, the local groundwater table mimics the topographic expression, always flowing in the direction of lesser hydraulic potential. Regional groundwater flow is towards the Schuylkill River, approximately one (1) mile west-northwest of the site.

Two aquifer zones have been defined by data generated from distinct multiple well sets placed within either the first 100 feet (the upper or shallow zone), or between 100 to 200 feet below ground surface (the lower or deep zone). Currently, no on-site well extends greater than 200 feet below the ground surface.

The groundwater system in the vicinity of the NGK site consists of a discontinuous unconfined aquifer including unconsolidated clay, sand and gravel overlying fractured bedrock. There is no confining layer between the different aquifer materials. However, the unconsolidated soil/bedrock zone has been identified as a primary groundwater flow path. Hydraulic conductivity values for the unconfined clay, sand, and gravel aquifer material were generally lower than values for the limestone bedrock.

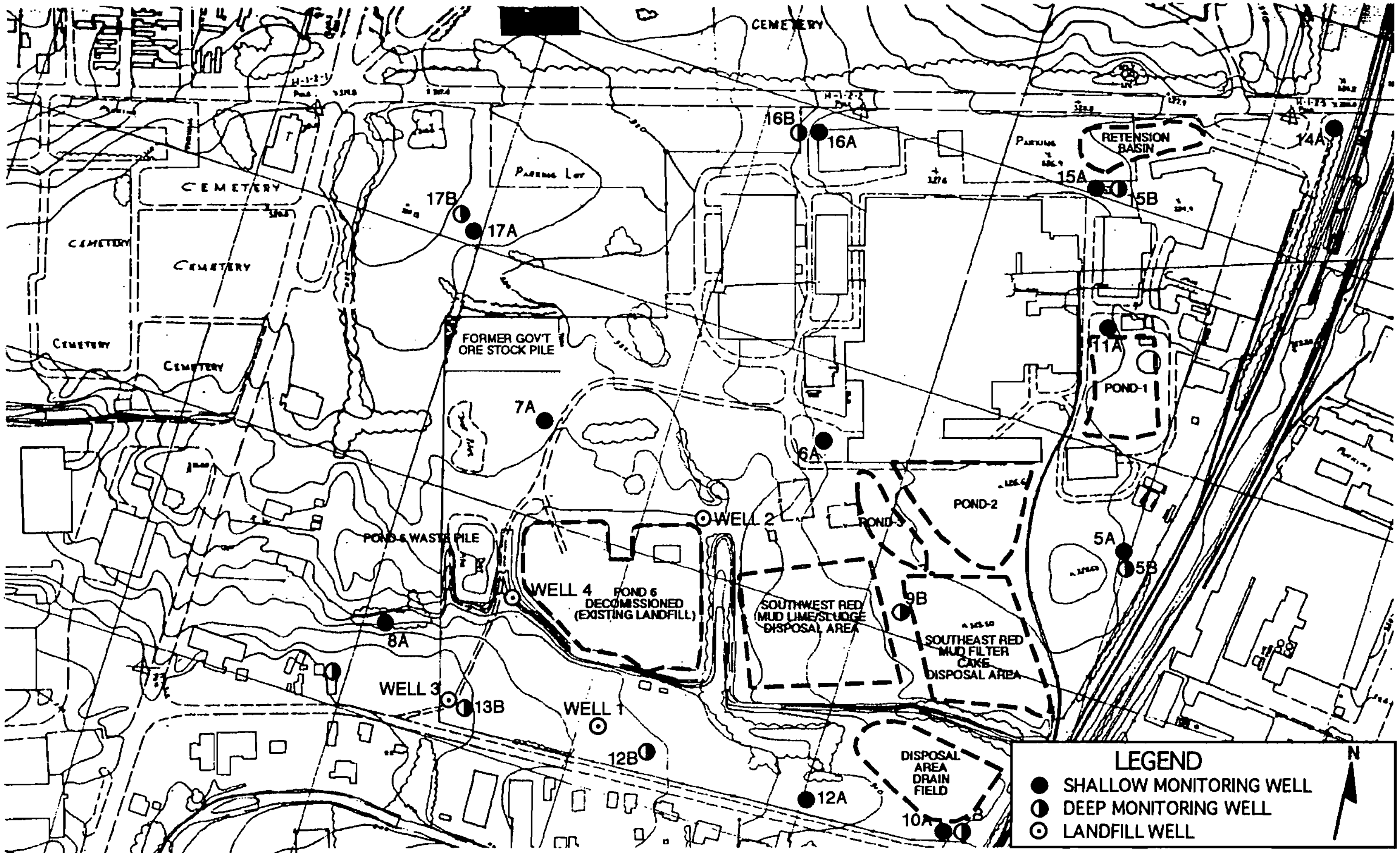
Groundwater flow within the bedrock is almost entirely controlled by secondary porosity due to fractures, and solution channels within the carbonate bedrock. Enhanced water-bearing zones appear less frequently in the northern one-third of the site. Monitoring wells here generally have lower yields than the remaining site wells. Wells in this area generally produce less than 3 gpm. Median yield is less than 2 gpm. A greater number of higher yielding wells are located in the southern two-thirds of the property. Average well yield in this area is greater than 17 gpm, with a median yield of greater than 5 gpm. On-site well yields range from less than 2 gpm to greater than 100 gpm.

1.4 Description of Solid Waste Management Units (SWMU)

Prior to the early 1950s and continuing through the mid 1960s a number of ponds or SWMUs were utilized at the current NGK site. The locations of these SWMUs are shown on Figure 1.3 - SWMU Location Map. The individual SWMUs are as described below.

1.4.1 Pond 1

Pond 1 was an unlined pond used for approximately ten years beginning in 1950 to settle sludge resulting from the neutralization of process waters. Lime was used to neutralize waste waters containing fluorides, spent acids, and acidic rinse waters.



DUNN

DUNN CORPORATION

Engineers, Geologists, Environmental Scientists

2 Market Plaza Way, Mechanicsburg, PA 17055

Phone: 717/795-8001 Fax: 717/795-8280

SWMU LOCATION MAP

RCRA CORRECTIVE MEASURES STUDY

NGK METALS CORPORATION

READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: 1"=300' APPROXIMATE	FIGURE NO.: 1-3

The pond was approximately 0.5 acre in area. In the early 1960s, most of the sludges were removed from the pond, and use of the pond was discontinued. The pond was filled with gravel and construction and demolition debris resulting from facility construction activities, and the filled area was covered with soil. NGK's current waste water treatment facility is partially located in the area of former Pond 1.

Waste liquids draining from the sludges may have seeped from the pond during its use. Waste residues in the pond contain concentrations of metals, including; beryllium, copper, cadmium, arsenic, nickel, antimony, cobalt, silver, and chromium. The waste residues are subject to leaching by precipitation infiltrating the area.

1.4.2 Pond 2

Pond 2 was also unlined and was designed to receive the effluent from Pond 1. The pond was approximately 0.75 acre in area. Use of this pond was also discontinued in the early 1960s, and the pond has since been leveled and covered with soil.

Waste water may have seeped from the pond during its use. Waste residues in the pond contain elevated concentrations of fluorides and metals, including; beryllium, cadmium, copper, nickel, cobalt, mercury, lead, and chromium. The waste residues are subject to leaching by precipitation infiltrating the area.

1.4.3 Pond 3

Pond 3 was unlined and was used for the storage of storm water runoff from the facility. This pond was approximately 0.3 acre in area. Use of Pond 3 was discontinued in the early 1960s, and the area was leveled and covered with soil.

Based on borings completed in this area, some process wastes are present. Red mud and metal debris have been found at depths up to 15 feet. Red mud is the residue material which was left over from the extraction of the ores which were processed at the NGK site until 1965. Waste materials in Pond 3 contain elevated concentrations of beryllium, copper, sodium, cobalt, and fluoride. Waste materials at the base of the pond are subject to leaching by precipitation infiltrating through the waste.

1.4.4 Southeast Red Mud and Filter Cake Disposal Area

The Southeast Red Mud and Filter Cake Disposal Area (also called Pond 4) was an unlined surface impoundment used for the disposal of red mud. Also disposed in this impoundment was filter cake resulting from the production of beryllium metal.

This disposal area is approximately 1.25 acres in size and contains approximately 15,000 cubic yards of wastes. Use of this area was discontinued in the mid-1960s, and the impoundment was leveled and covered with soil. Based on historical analyses, the waste materials formerly disposed in the pond contained fluorides and metals, including

copper, beryllium, cobalt, nickel, and zinc. Waste residues are subject to leaching by precipitation infiltrating the wastes.

1.4.5 Southwest Red Mud and Lime Disposal Area

The Southwest Red Mud and Lime Disposal Area (also called Pond 5) was an unlined surface impoundment used for the disposal of red mud and lime sludge. The red mud resulted from the processing of beryl ores and the lime sludge resulted from neutralization of process waste waters. This disposal area is approximately 0.75 acre in area and contains approximately 16,500 cubic yards of wastes. Use of this area was discontinued in the mid-1960s, and the impoundment was leveled and covered with soil.

Waste materials disposed in the pond contain fluorides and metals, including beryllium, copper, and cadmium. The waste residues are subject to leaching by precipitation infiltrating the wastes.

1.4.6 Retention Basin

The former "Retention Basin" is located at the northeast corner of the NGK facility and is currently paved and used as a parking lot. The basin is estimated to have been approximately 0.4 acres in area. The historic use of the Retention Basin is not documented. Based on an examination of historic aerial photos, the basin appears to have been used as a part of the facility's storm water management system. Use of the basin was discontinued in the late 1940s and the area was filled. Borings completed in the basin indicate some red mud is included in the fill materials placed in the basin. Samples taken from the fill contain relatively low concentrations of fluorides, nitrates, chlorides, and metals, including nickel, cobalt, zinc, copper, and beryllium.

1.4.7 Soil Stock Pile Near Former Pond 6

In the late 1970s, a new permitted landfill was constructed on site for the management of plant wastes in the location of Pond 6. During the construction of the landfill, the soils and remaining sludges in Pond 6 were removed and are currently stockpiled on site in an area immediately west of the former location of Pond 6. Pond 6 was an unlined impoundment used for the disposal of lime sludges which were periodically removed from Pond 1. The wastes in the stockpile are composed of soils and sludges resulting from the use of lime to neutralize wastewater containing fluorides and acids.

The stockpiled waste materials are subject to leaching by precipitation infiltrating the wastes and may adversely affect groundwater quality due to leaching. Waste materials in the stockpile are also subject to erosion by surface runoff and wind which may result in transport beyond the facility boundaries.

1.4.8 Drain Field Area

The former drain field area is located at the southeast corner of the facility. The drain field was approximately 0.6 acres in area. It is unknown what uses were made of the drain field. Although it may have received treated waste waters from other SWMUs until they were capped in the early 1960s, it does not appear that red mud entered the disposal area drain field. Samples collected at the drain field contain metals, including beryllium, cadmium, chromium, cobalt, and copper.

1.5 Summary of RFI and HHE Findings

If left unchanged, the conditions at the NGK property indicate that one theoretical exposure pathway may pose a potential long-term health concern. This is the routine ingestion of groundwater by on-site workers and off-site residents. It should be noted however that groundwater is not used for consumption at the NGK property. Also, there are no known off-site wells for drinking water purposes that are being used and which contain levels of site-specific chemicals that would result in a potential long-term health concern. A summary of site-specific chemicals of concern at the NGK facility is presented in Table 1.1 - Levels of Site Specific Chemicals Detected in Various Environmental Media.

1.5.1 Mechanism For Release

The principal route by which people and the environment may potentially be exposed to the wastes disposed at the NGK facility is due to the leaching of trace amounts of the waste constituents into the groundwater. If left uncontrolled, these contaminants may continue to migrate and adversely effect groundwater downgradient of the facility.

Additional potential exposure pathways that pose insignificant risks as identified and discussed in the NGK Human Health Evaluation and Ecological Assessment include:

- People may also be exposed to the waste materials if present at the surface of the facility. Waste residues or contaminated soil exposed at the surface may result in exposure due to direct contact, ingestion, or inhalation of particulates. The waste materials are, however, not exposed at the surface of the facility and any possibility of direct contact is minimal.

- If exposed, waste residues and contaminated soils may be released into the environment with surface runoff and the wind. Waste constituents carried off-site as a result of erosional processes may result in human exposure via inhalation of contaminated suspended particulates, or dermal contact with or ingestion of contaminated materials. The waste materials are, however, not exposed at the surface and erosion has not occurred.

Table 1-1

Levels of Site-Specific Chemicals Detected in Various Environmental Media

	Soil (2)			On-site Groundwater			Off-site Groundwater				Surface Water			Sediment			Air (3)		
Analytes	Min	Max	Avg	Min	Max	Avg	Min	Max	Location	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Beryllium	737.0	945.0	814.0	0.0002*	0.55	0.07	0.0002*	0.0084	MW 26	0.004	0.0002*	0.0009	0.0008	0.24	1.77	1.14	0.00011	0.00079	0.000352
Chromium (Hex)				0.01*	1.30	0.21	0.01*	0.24	OS-1	0.046	0.01*	-	-	0.011*	-	-			
Total Chromium	129.0	227.0	167.0	0.001*	1.69	0.30	0.005*	0.24	OS-1	0.047	0.002*	0.042	0.012	4.6	10.0	7.2	0.00145	0.00616	0.003460
Copper	2730.0	4910.0	3667.0	0.0025*	0.27	0.06	0.0025*	0.104	BP-1	0.030	0.0025*	0.033	0.021	3.7	86.13	38.30			
1,1-Dichloroethene				0.001*	0.03	0.004	0.001*	0.0013	OS-1	0.0006	0.001*	-	-	0.005	-	-			
Fluoride	62.1	140.0	93.6	0.200	128.30	21.20	0.10	1.60	OS-1	0.580	0.12	0.87	0.35	0.1	12.52	6.65			
Selenium	0.1	0.3	0.2	0.001*	0.04	0.005					0.001*	-	-	0.24*	0.82	0.39			
Trichloroethene				0.001*	0.008	0.002	0.001*	0.0035	OS-1	0.0009	0.001*	-	-	0.001*	-	-			
Cadmium (1)	37.2	60.1	50.8																

All data are in parts-per-million (ppm)

(1) Cadmium selected as a site-specific chemical for soils only

(2) All soil data are from samples collected from the Disposal Area Drain Field

(3) air data are in µg/cu m -- not in ppm

OS-1 is Off-Site Well Number One and BP-1 is Berks Products off-site well

Legend:

- \- :not detected above reporting limit
- * :not detected at or above listed reporting limit

Blank space means that the specific substances were not anlayzed for in that medium.

1.5.2 Nature of Release

Metals (chromium, and cadmium), fluorides, and organic solvents (trichloroethylene and 1,1-dichloroethylene) have been measured in groundwater beneath the NGK facility at concentrations which exceed the National Primary Drinking Water Standards. There is no current Drinking Water Standard for beryllium. If left uncontrolled, these contaminants may continue to migrate and adversely effect groundwater downgradient of the facility.

2.0 OBJECTIVE OF THE CORRECTIVE MEASURES STUDY

The goal of the Corrective Measures Study for the NGK Metals Corporation facility is to develop a comprehensive corrective measure program which will protect human health and the environment from actual or potential future releases of hazardous wastes or hazardous constituents from the facility. The corrective measure selected for the NGK facility will essentially eliminate or substantially reduce the potential for human or environmental exposure by the exposure pathways described in Section 1.5.

The corrective measure selected will:

- minimize the potential for human exposure to waste constituents contained in waste materials or contaminated soils in excess of accepted, risk-based criteria; and,
- minimize the discharge of affected groundwater from the NGK facility; and,
- restore the property to the point that it can be used for purposes appropriate to the property and consistent with NGK' s needs.

2.1 Identification of Potential Technologies

Technologies have been selected for consideration in the development of a comprehensive corrective action program for the NGK facility based upon the following:

- Site Characteristics: the characteristics of the NGK facility and its surroundings;
- Waste Characteristics: the characteristics of the NGK wastes and the environmental media affected by the wastes; and,
- Technology Limitations: the limitations of the technology to effectively and reliably meet the objectives of the corrective action program.

The technologies which will be considered for application in the corrective measure program at the NGK facility are those which have been demonstrated effective in a full-scale remedial program involving similar wastes and similar site conditions. Emerging technologies were examined to determine if they were applicable to the specific conditions which exist at the NGK facility. Any technology for which there was insufficient usable or applicable data was not considered further.

It is the purpose of the CMS to identify technologies which may have application in the treatment and management of the waste materials, contaminated soil and groundwater, and to evaluate the potential for each technology to be successfully applied in the corrective action program.

3.0 CRITERIA USED IN THE EVALUATION OF TECHNOLOGIES

This section presents the the criteria that will be used to evaluate each of the technologies identified in Section 4. The detailed evaluation of each corrective measure alternative will include the following:

- A brief description of the potential corrective measure emphasizing the application or the technologies; and

- A detailed evaluation considering effectiveness, implementability, and cost of the remedial alternative.

3.1 Evaluation Process

The criteria which will be used to evaluate the corrective measure alternatives include the following parameters:

- Anticipated short-term effectiveness
- Anticipated long -term effectiveness and performance
- Reduction of toxicity, mobility, and/or volume - reliability
- Implementability
- Cost
- Overall protection of human health and the environment

Each potential corrective measure will be evaluated with respect to the above factors, as described in the following sections.

3.2 Effectiveness

At this stage of the corrective measures study, the assessment of anticipated effectiveness is primarily based on experience or published literature which documents that the technology has been successfully used in a full-scale application in a similar setting.

3.2.1 Anticipated Short-Term Effectiveness

The anticipated short-term effectiveness of the technology is an assessment of the technology relative to its effect on human health and the environment during its implementation. The short term assessment is based on four components:

- Risk that may occur to the local community during implementation of the corrective measure alternative.

- Potential risk to the worker during implementation of the corrective measure alternative.

- The potential for adverse environmental impacts that may occur as a result of implementation of the corrective measure alternative.

- The time required for the corrective measure alternative objectives to be met.

3.2.2 Anticipated Long-Term Effectiveness and Performance

The assessment of a corrective measure alternative relative to its long-term effectiveness and performance is made taking into account the risks that will remain after the corrective measures have been implemented. The following areas are evaluated in the assessment.

- The level of residual risk remaining at the completion of the corrective measure alternative

- The adequacy and suitability of containment systems and/or institutional controls used to manage treatment residuals or untreated materials remaining at the site.

- An assessment of the long-term reliability of containment systems and/or institutional controls to provide continued protection from treatment residuals or untreated materials.

3.3 Reliability – the Reduction of Toxicity, Mobility and/or Volume

This evaluation addresses the ability of the potential corrective measure alternatives to reduce toxicity, mobility and /or the volume of hazardous substances contained in the waste materials. The evaluation addresses the following factors:

- The treatment processes, the technologies used, and the waste constituents treated.

- The quantity of hazardous materials that will be treated or destroyed.

- The expected reduction in toxicity, mobility or volume.

- The type and quantity of treatment residuals that will remain after completion of the corrective measure alternative.

3.4 Implementability

Implementability is an assessment of the feasibility and the ease with which the technology may be applied at the NGK facility. Implementability refers to the technical

and administrative feasibility of implementing an alternative. Implementability takes into consideration such practical factors as:

- Technical Feasibility: The relative ease of implementing or completing an alternative based on the use of established technologies, site specific constraints, ability to consistently meet performance goals and the ability to monitor the effectiveness of the corrective measure alternative.

- Administrative Feasibility: Activities needed to coordinate with other regulatory bodies or agencies(e.g., obtaining permits for off-site activities or rights-of-way for construction plus environmental operating permits such as those required for RCRA, NPDES, or stormwater)

- Availability of Services and Materials: The availability of the necessary equipment and resources required to complete the project.

3.5 Costs

For each corrective measure alternative, a cost is developed. Cost estimates are based on conceptual engineering and analyses, and are expressed in terms of 1992 dollars. All costs are rounded to two significant figures. The cost estimate for a corrective measure alternative consists of three components:

- Capital Costs - Capital costs consist of direct and indirect costs. Direct costs include costs for equipment, labor, and materials required to construct and implement a corrective measure alternative. Indirect costs are expenditures for engineering, financial, and other services that are not actually a part of the construction, but are required to implement a corrective measure alternative. Costs for obtaining rights-of way are not included as these are site specific costs for which estimates can not be made.

- Operation and Maintenance Costs (O & M) - O & M costs are those post construction costs that are necessary for the continued effectiveness of a corrective measures alternative. Typically these costs include items such as long-term power costs, mechanical equipment and site maintenance costs, equipment replacement costs, long-term monitoring costs, and chemical costs for waste water treatment.

- Analysis of Present Worth - This analysis is used to evaluate the capital and O & M costs of a potential corrective measure alternative based on a present worth basis. This assessment allows the comparison or corrective measure alternatives on the basis of a single cost. A 30 year performance period is assumed for the present worth analyses. A discount rate of 8% is assumed for the base calculations.

The corrective measure alternative cost estimates developed for the CMS are intended to provide an additional basis for cost comparison between alternatives. These are order of magnitude costs estimates with an accuracy of -30% +50%. The final cost of the selected alternative will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, rights of way costs as appropriate, and other variable factors.

3.6 Overall Protection of Human Health and the Environment

In this evaluation, an overall assessment of protection of human health and the environment is made. This assessment is based on a number of factors assessed under other evaluation criteria. Those specifically considered are short-term effectiveness, and long-term effectiveness and performance. Each corrective measure alternative evaluation will include:

- How each source of contamination is to be eliminated, reduced, or controlled; and

- How the site risks are to be reduced.

4.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES - AFFECTED SOILS AND WASTE MATERIALS

The identification of technologies which may have application in a corrective action program at the NGK facility has been based on: (1) conditions at the NGK facility, (2) the types of wastes present at the facility, and (3) the nature and volume of affected environmental media resulting from releases at the facility. The technologies which may be applicable at the NGK facility are described below. The technologies considered may have application in one or more of the following:

- In the management /treatment of the waste muds or sludges which are present on the facility;
- In the restoration of groundwater quality and/or control of groundwater movement; and
- In the treatment of affected groundwater recovered as a part of the corrective action program

A key and primary goal is to prevent water, in any form, from contacting the wastes or affected soils. Whether specifically described in this document or not, the technologies which will be employed to prevent water contact with the wastes or affected soils will be selected on the basis of both performance and cost. NGK Metals will accomplish the stated performance goal of hydraulic isolation of the wastes and soils by substituting, combining or employing technologies with demonstrated effectiveness.

4.1 Surface Water Controls

Surface water controls reduce the potential for erosional losses of contaminants. Surface water controls are also designed to reduce the amount of water which has the potential to infiltrate through the wastes at the site. In reducing the amount of infiltration, the potential for leaching of contaminants and the resultant contamination of groundwater are reduced.

4.1.1 Control of Water Running onto the Site

"Run-on" controls include drainage swales to intercept water which would otherwise run onto the NGK facility or specific areas of concern. "Run-on" controls also include berms to redirect water which would otherwise run onto the site. "Run-on" controls may require improvements to the existing storm water management system.

4.1.2 Improving Surface Drainage

Drainage improvements will promote drainage of water from the site, reducing the potential for water to infiltrate the areas of concern. Such controls include lined swales, additional catch basins and improved storm sewers. Additional areas of the site could

be paved and provisions made to collect storm water on paved surfaces and route it to storm sewers. Portions of the site near the SMWUs can be regraded to promote runoff which will also reduce the potential for infiltration.

4.2 In-situ Isolation Technologies

The landfilled wastes and the significantly affected soils can be further isolated from the environment which will further reduce the potential for human or environmental exposures. Technologies which may have application in isolating the NGK wastes are discussed below.

4.2.1 Capping

Capping involves the placement of low permeability cover materials over the areas of concern. The low permeability covers are graded to drain freely and result in a significant reduction in the amount of infiltration which may leach contaminants from the wastes or the soils and contaminate groundwater. Capping also essentially eliminates the potential for direct human exposure to the wastes via inhalation, ingestion, or dermal contact, and, will eliminate erosional losses of contaminants from capped areas via surface runoff or wind.

Low permeability covers which may be used in the construction of a cap at the NGK facility include:

- Synthetic membranes
- Clays/soils
- Asphalt /geotechnical
- Concrete/geotechnical

The use of clayey soils to construct a low permeability cover to isolate wastes from the environment is a technology frequently applied in waste management. The types of soils needed, the expected performance, and the quality controls necessary to achieve the desired performance are well documented. The use of synthetic membranes in the construction of caps is also a well developed and commonly applied technology. Because the clayey soil or synthetic membrane must be covered with additional soil to protect the "barrier" layer from damage due to erosion, burrowing animals, frost, etc., the final cap may be several feet thick. In areas of the facility where a cap several feet thick may interfere with the other necessary uses of the property, consideration will also be given to use of paving materials to construct the low permeability cover. Paving is a well developed construction technology which can provide many of the environmental benefits of more sophisticated caps.

Due to the nature of the red mud and other buried materials at the NGK site, the evaluation of a gas collection system is not required. Typically, a gas collection system is installed beneath the cap to relieve gas pressure and to collect any gases which may be generated during decomposition of organic wastes. Since the wastes at the NGK site are of an inorganic nature, no gas generation or build-up is anticipated. Cross sections of different types of caps are presented in Figures 4.1 - 4.4. These caps differ in their ability to reduce infiltration, the cost to construct and maintain, and, to some extent, in the difficulty of construction.

The capped wastes will require monitoring to insure that the cap is performing as designed. The cap will also require periodic maintenance of the vegetative cover, and repair of areas affected by differential settlement, erosion, or cracking.

4.2.2 Slurry Walls

The landfilled wastes may be further isolated from the surrounding groundwater system by constructing a slurry wall around the area(s) of concern. Equipment is available to excavate trenches to the anticipated depth of bedrock (generally less than 60 feet). The trench would be filled with a mixture of the excavated soil, bentonite clay and/or cement. The soil mixture placed in the trench would have a lower permeability than the existing soils and the potential for laterally moving groundwater to carry contaminants away from the areas of concern would be significantly reduced.

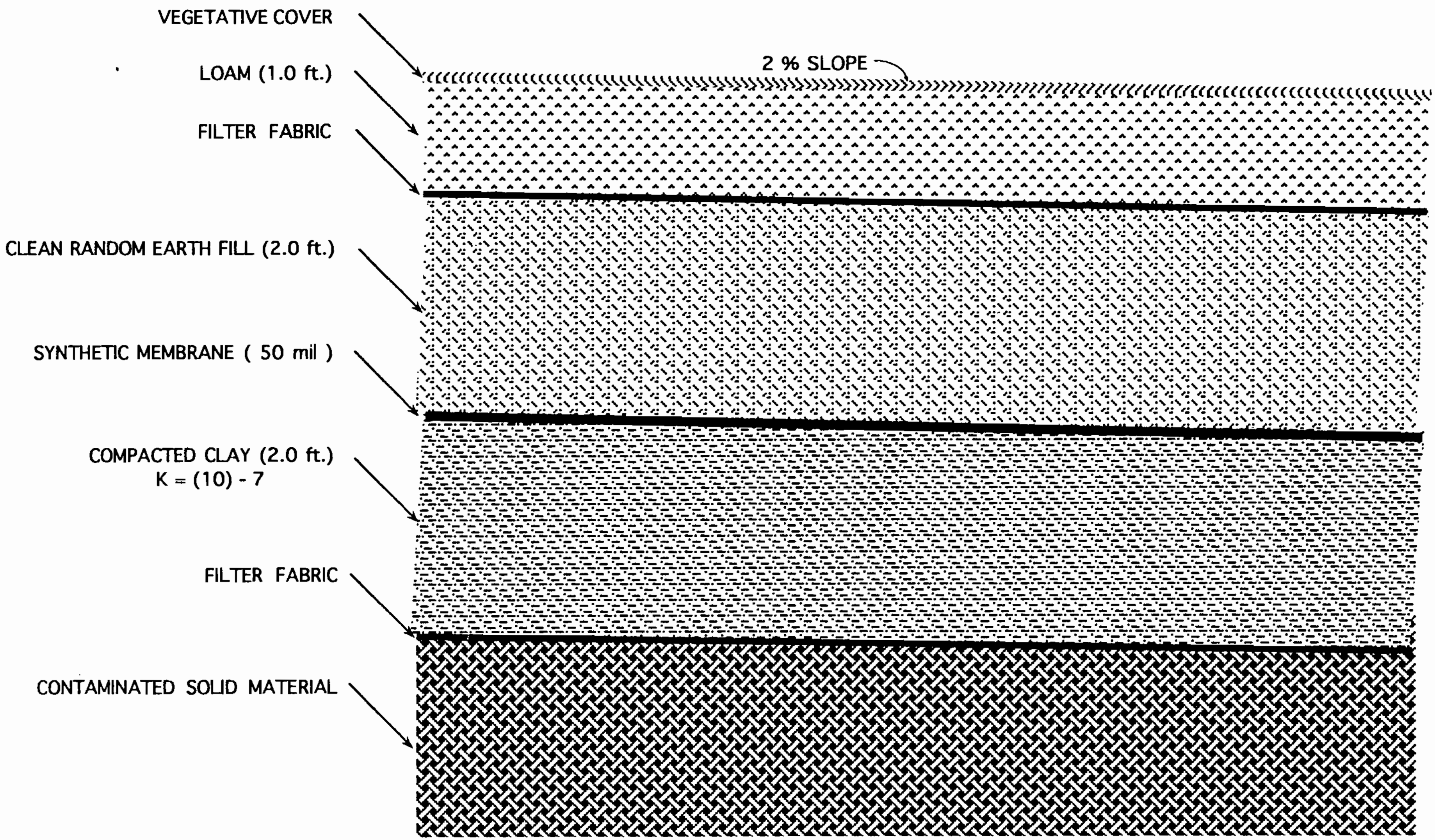
A long-term monitoring program would be required to determine the effectiveness of the slurry wall.

4.3 In-Situ Treatment of Waste Materials/Soils

The waste materials at the NGK site appear to be amenable to treatment in place (in-situ). The in-situ treatment technology which may have application is solidification/stabilization.

4.3.1 Solidification/Stabilization

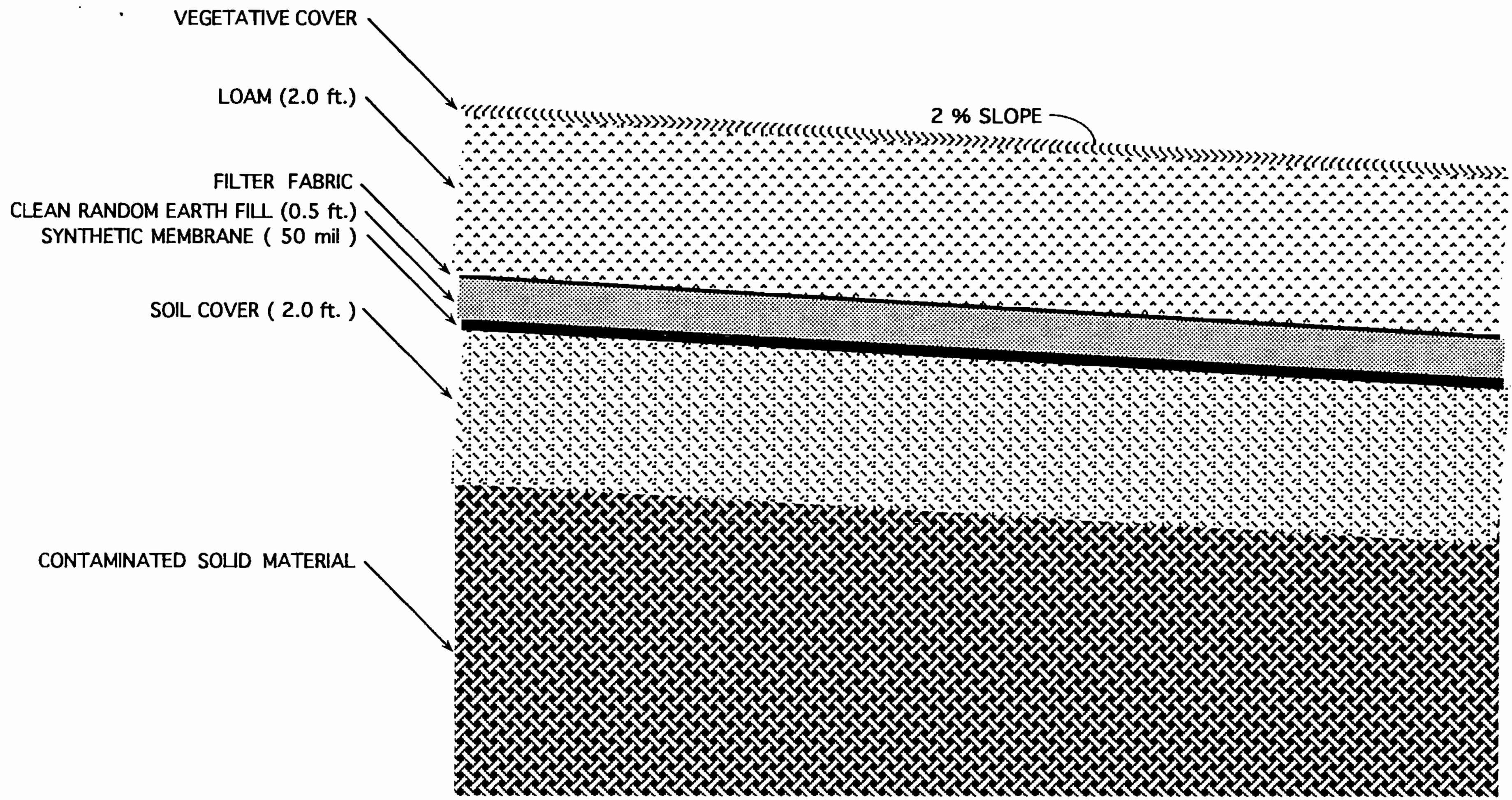
Solidification/stabilization technology may have application in the treatment of the red mud and other waste materials. In-situ solidification/stabilization involves the introduction of a solidifying agent (commonly cement-based or pozzolanic-based) into the wastes or affected soils and mixing the materials in place. Large augers are typically used to mix the materials. The wastes become physically, and in the case of certain metals, chemically immobilized in the solidified matrix. Use of Portland cement, lime, or other similar alkaline binding agents with NGK wastes will have the additional benefit of raising the pH in the wastes. Increasing the pH in the wastes will reduce the solubility of the metal contaminants and further reduce the potential for release into the environment.



DUNN
DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

RCRA MULT-LAYER CAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-1

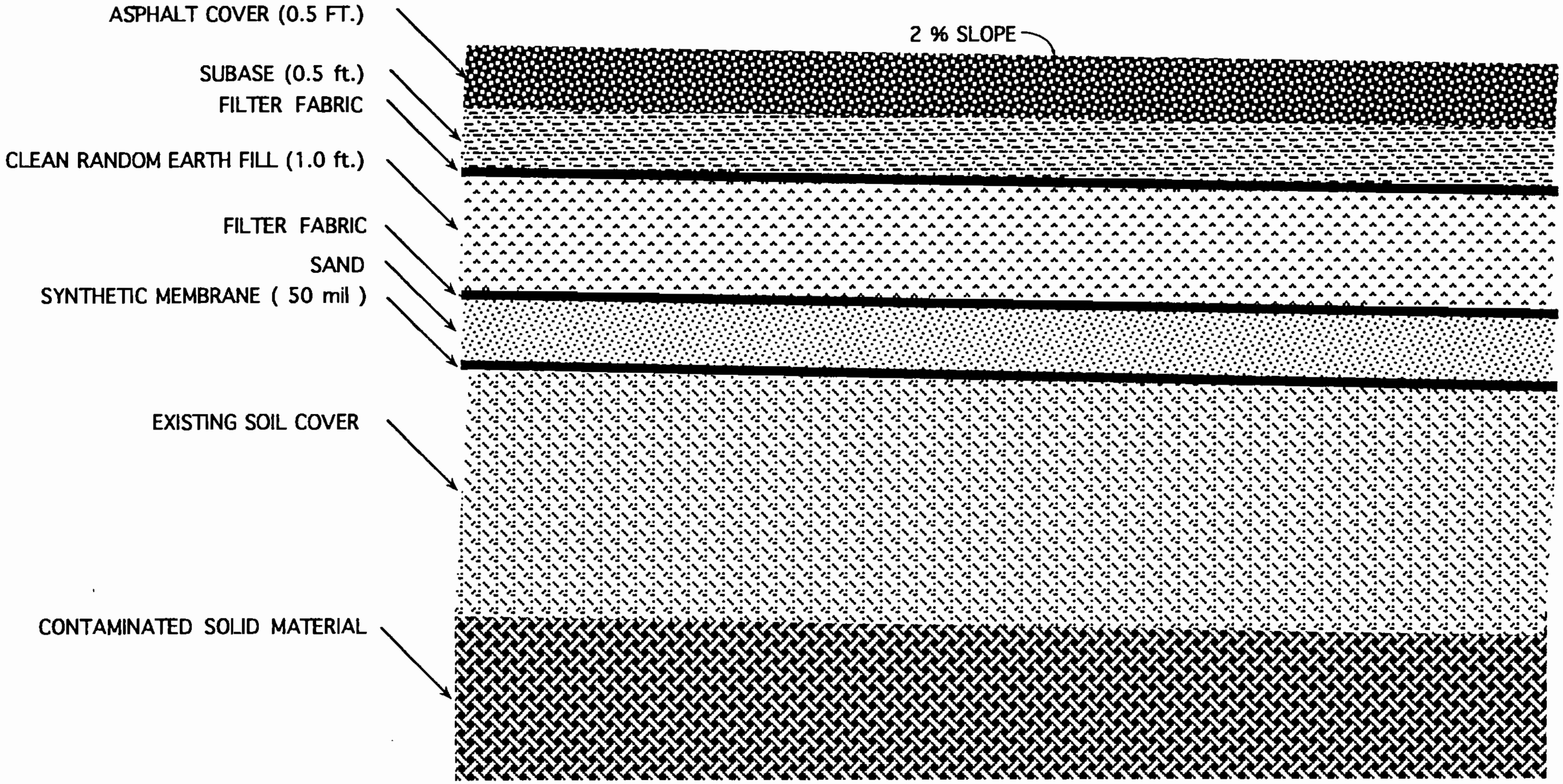


DUNN

DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

MODIFIED PENNSYLVANIA MULT-LAYER CAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

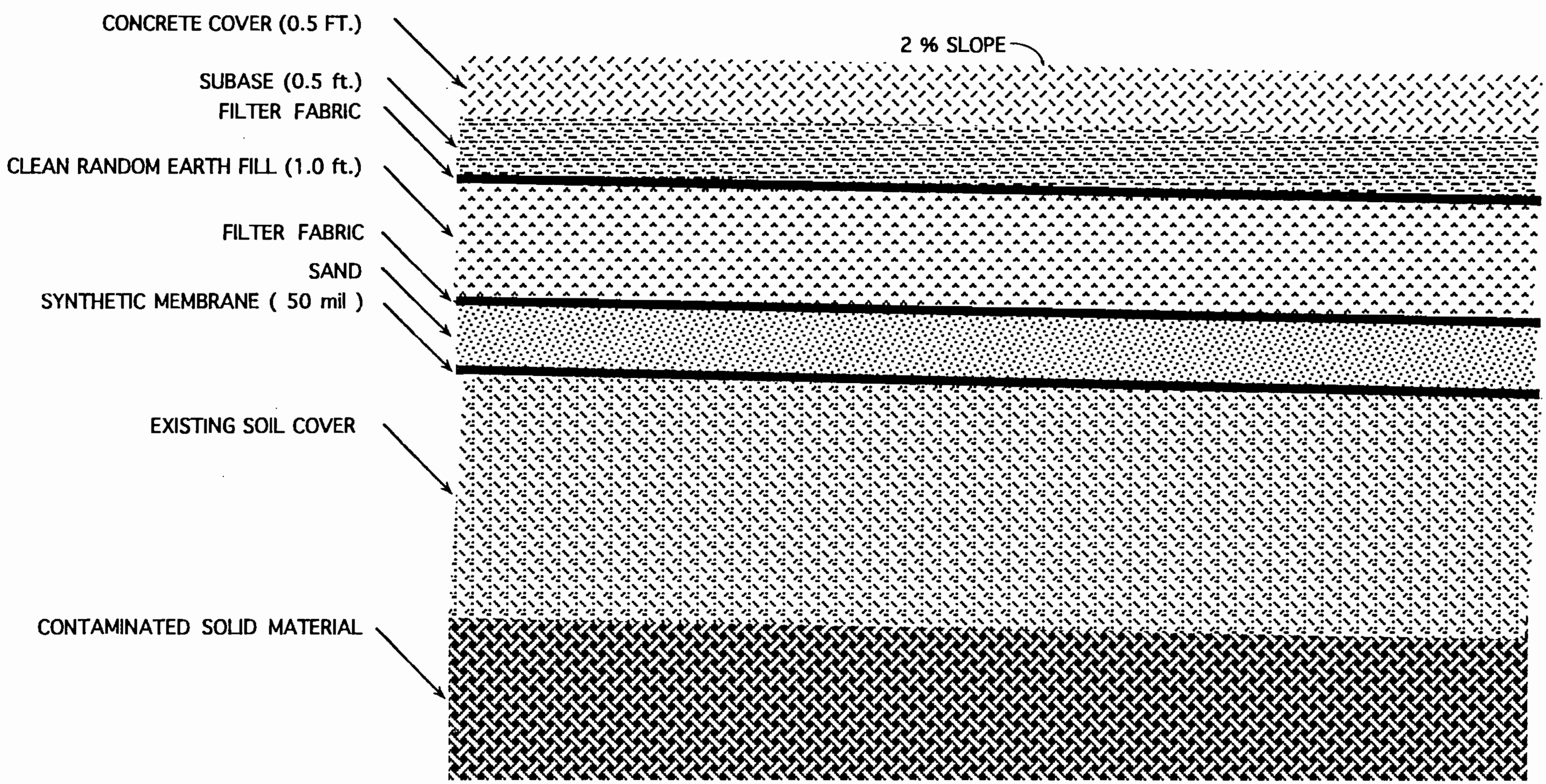
PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-2



DUNN
DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

ASPHALT/GEOTECHNICAL CAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-3



DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

CONCRETE/GEOTECHNICAL CAP
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-4

A long-term monitoring program would be required to determine the effectiveness of the solidification/stabilization process. Maintenance would be required to protect the stabilized wastes from physical damage (weathering and erosion) which may increase the potential for erosional losses and leaching of the hazardous constituents.

4.3.2 Vitrification

Vitrification technology may have application in the treatment of the red mud and other waste materials. Vitrification uses large amounts of electricity, applied through electrodes, to vitrify the silica present in the soil. Graphite is placed upon the soil surface to connect the electrodes. The heat generated from this system causes a melting that gradually works downward through the soil. Contaminants are trapped within the melted silicates that cool to form a strong, dense glass.

4.4 Excavation of Buried Wastes

The red mud and other waste materials can be removed from their current locations and subsequently managed in a manner which is protective of public health and the environment. Equipment capable of excavating the wastes is readily available.

If waste materials are excavated, portions of the material may become regulated as a "characteristic" hazardous waste due to the leachability of hazardous constituents. It is possible that cadmium and chromium, and possibly organic solvents may leach from the wastes in concentrations which will exceed the regulatory limits as set forth in 40CFR, Part 261. A characteristic hazardous waste must first be treated before the waste may be disposed of on land. Technologies which may have application in the treatment of NGK wastes to remove the characteristic of excessive leachability are described in Section 4.5 which follows.

4.5 Ex-situ Treatment of Wastes on Site

Excavated wastes may have to be treated at the NGK facility. The technologies which may have application in the treatment of wastes and affected soils are described below.

4.5.1 Stabilization/Solidification

Ex-situ stabilization/solidification technologies use equipment similar to that used to mix concrete. As discussed in Section 4.3.1, waste materials are physically incorporated into a low permeability matrix using binding agents such as Portland cement or pozzolans which significantly reduce the potential for future release. Use of Portland cement, lime or other similar alkaline binding agent with the NGK wastes would have the additional benefit of raising the pH of the wastes. By increasing the pH in the wastes, the leachability of the hazardous metal constituents is reduced, further reducing the potential for releases into the environment.

Once mixed, the stabilized wastes could either be placed and managed on the NGK facility, or transported to a suitable, off-site, landfill.

Use of solidification/stabilization technology would essentially eliminate the future potential for human exposure due to dermal contact, inhalation, or ingestion. The stabilized wastes would also be much less susceptible to leaching of the hazardous constituents.

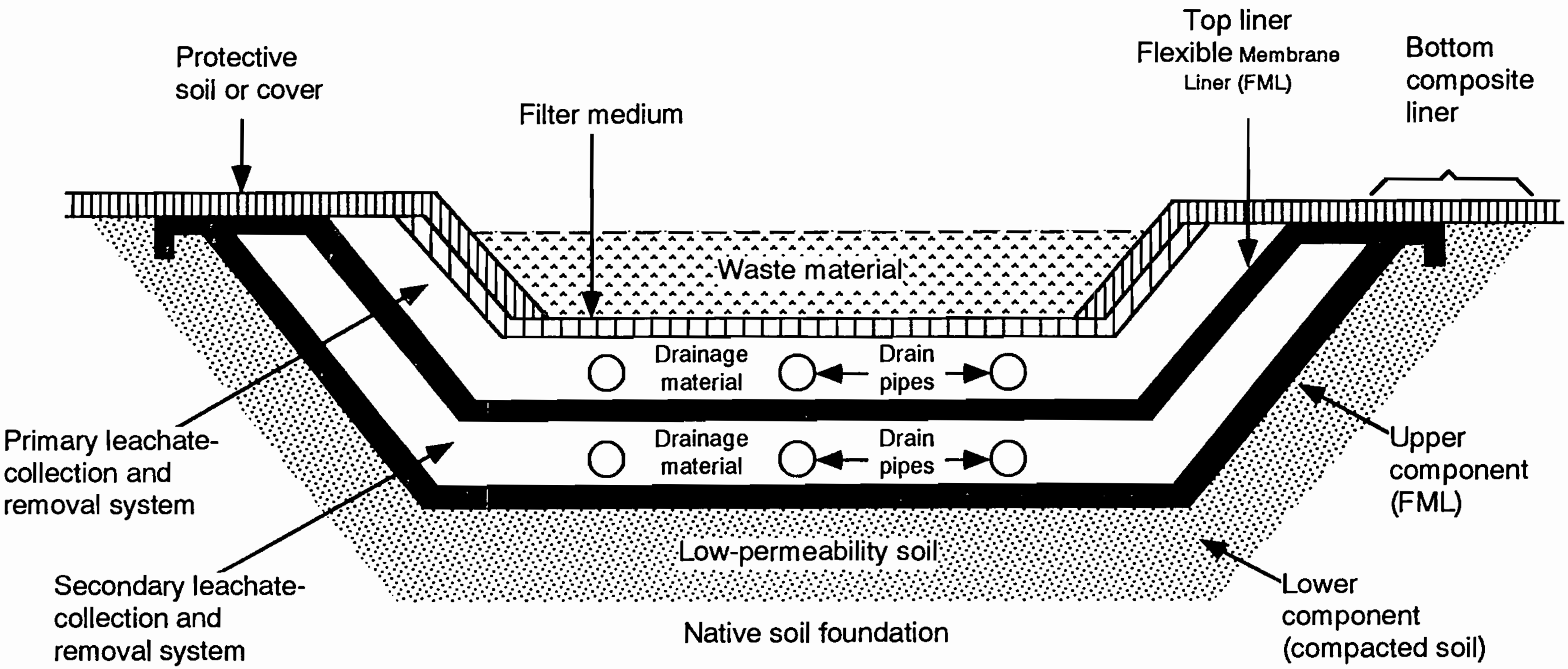
A long-term monitoring program will be required to verify that the stabilized wastes were not being released into the environment and maintenance would be required to protect the stabilized wastes from physical damage (weathering and erosion) which may increase the potential for erosional losses and leaching of the hazardous constituents.

4.6 On-Site Landfilling

Based upon existing analytical data, it appears that much of the waste material present at the NGK facility is not a regulated hazardous waste. Non-hazardous solid wastes and non-hazardous residuals resulting from the treatment of waste materials can be managed by isolating the wastes in a suitably lined solid waste landfill constructed on the NGK facility. Landfill liners are constructed of layers of low permeability soils and/or man-made membrane materials. Management of the wastes in a lined landfill provides an additional measure of protection to the underlying groundwater. A properly lined landfill will retain water which drains from the wastes . By including a collection system in the base of the lined landfill, any moisture retained by the liner can be removed for proper treatment and disposal, thus reducing the potential for a release to groundwater. Any leakage through the primary liner will be retained by the secondary liner thus facilitating the removal of any leakage should any occur. Further, upon completion of the landfilling of the wastes, an impermeable cap will be required to minimize or eliminate water entering the deposited waste. Thus, leachate production will eventually cease completely and no liquid waste treatment will be required.

Typical cross sections of alternative landfill liners are presented in Figures 4.5 and 4.6. The wastes placed in the lined landfill would be capped with suitable cover materials (see Section 4.2.1) to minimize or eliminate any possible infiltration and to minimize the opportunity for direct human exposure to the wastes via dermal contact, ingestion, or inhalation. A cap would also prevent erosional losses of wastes which might adversely affect surface runoff and/or air quality. Excavated areas would be filled with clean soil and the restored area could be used by NGK consistent with any future plans for the facility.

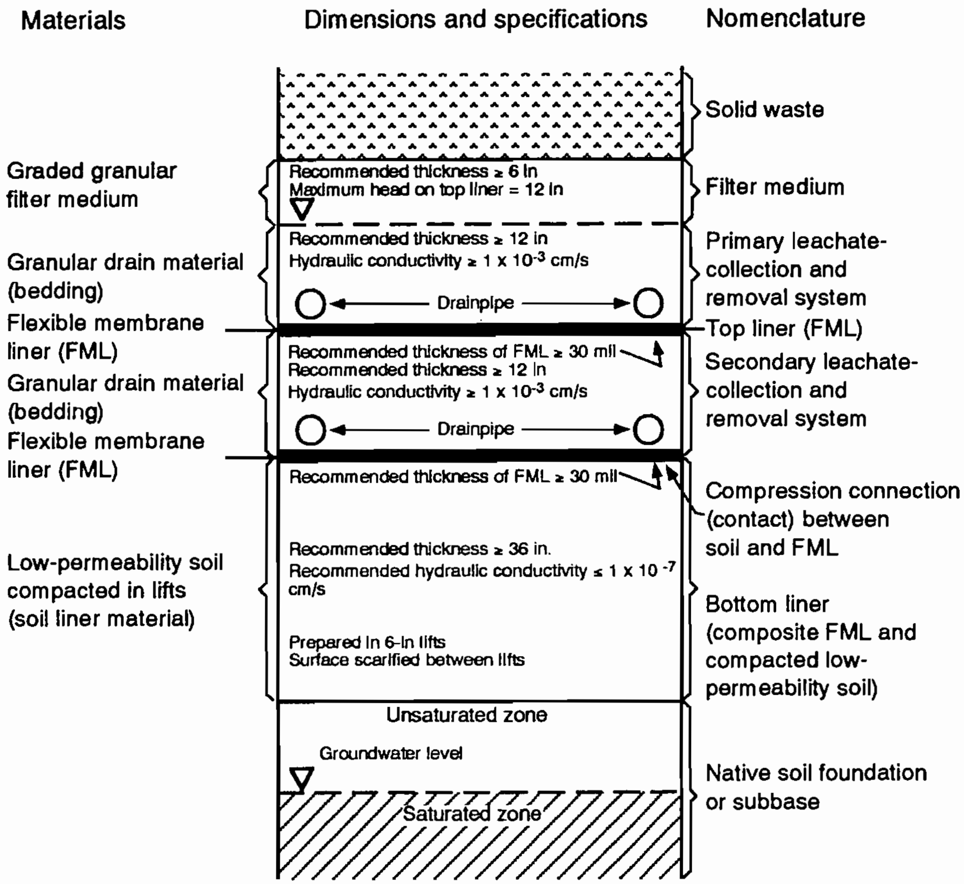
Management in a lined landfill will also require periodic monitoring to verify that the landfill is performing as designed. The landfill will also require operation to remove and to provide treatment of any leachate which is collected. The cap will require maintenance to minimize erosional losses and to assure its continued integrity.



DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280
DUNN

RCRA LANDFILL LINER CROSS SECTION
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-5



DUNN

DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

RCRA LANDFILL LINER DETAIL
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 4-6

4.7 Off-Site Land Disposal

Based upon existing analytical data, it appears that much of the waste material present at the NGK facility is not a regulated hazardous waste. Non-hazardous solid wastes and affected soil which might be excavated as a part of the corrective action program at the NGK facility could be transported off-site for disposal at a properly permitted, solid waste management facility. Excavated materials that require treatment before land disposal could be treated at the NGK facility using the technologies described in Section 4.5 above. It is anticipated that treated materials could also be transported off-site for proper disposal as a non-hazardous, solid waste.

4.8 Off-Site Treatment and Disposal

Excavated waste materials which are regulated as a hazardous waste may also be treated at a properly permitted off-site facility. Treatment technologies which may be available at off-site facilities are described below.

4.8.1 Solidification/Stabilization

Wastes which are regulated hazardous wastes due to the characteristic of excessive leachability of metals or organics may be treated at an off-site facility by means of solidification/stabilization technology (described in Section 4.5.1).

4.8.2 Low Temperature Thermal Processing

Wastes which are regulated hazardous wastes due to the presence of excessive amounts of regulated organics may be treated at an off-site facility by means of low temperature thermal processing. Low temperature thermal processing consists of roasting the soils to drive off the offending organics and capture them for destruction.

5.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES - AFFECTED GROUNDWATER

5.1 Recovery and Control of Affected Groundwater

The groundwater beneath the NGK facility has been in contact with or affected by the wastes and/or affected soils which are present on the property. It contains low levels of inorganic and organic constituents which are characteristic of the wastes and may have originated from them. It should be noted that removal of wastes will not totally eliminate the source groundwater contamination as residual contaminants will remain in the vadose zone at the site.

Studies have determined that it is possible and feasible to intercept, recover and control the groundwater prior to the time it leaves the NGK facility. Recovery of the groundwater will allow its treatment through advanced processes and make it available for appropriate uses or disposal.

5.1.1 Extraction Wells

The movement of groundwater can be controlled by pumping at controlled rates through carefully placed extraction wells. Extraction wells will help control local groundwater table elevations to restrict the movement of affected groundwater off-site and to recover it for treatment. Extraction of affected groundwater will enhance the rate of improvement in groundwater quality as contaminants are removed from the aquifer.

The soils present upon the NGK facility have a relatively low permeability and the bedrock is fractured and karstic. The design, therefore, of an effective extraction well system required complex computer modelling of the area groundwater. The numerical computer model used to predict the hydraulic behavior of the saturated unconsolidated and consolidated aquifer materials in the vicinity of NGK is the U.S. Geological Survey three dimensional finite difference groundwater flow model.

The existing groundwater flow patterns and aquifer properties were first determined after approximately fifty simulations, using site data. Then anticipated flow patterns, under new conditions imposed by the simulated pumping of strategically located extraction wells, were determined.

Although the model used is a simplification of the actual on-site groundwater system, the results corresponded sufficiently well with observed conditions to warrant confidence in the predictive capacity of the model for the NGK site. It should be recognized, however, that absolute predictability for the NGK site is very unlikely because of its complex, highly heterogeneous nature and underlying geological terrain.

An extraction well system requires operating personnel and regular maintenance. It will also require a long-term monitoring program to determine whether the system is performing as designed.

5.1.2 Interceptor Trenches

Affected groundwater movement may also be controlled by the construction of interceptor trenches. Interceptor trenches are excavated to a depth extending below the water table and are backfilled with highly permeable materials such as a uniformly sized, clean, crushed stone. Groundwater which enters the trench can be removed by pumping from wells or sump pits installed in the highly permeable backfill. A continuous trench collection system makes it easier to establish a continuous depression in the groundwater table, thus minimizing the possibility of groundwater circumventing the control. Interceptor trenches may have application on the portions of the NGK facility where the affected groundwater is present in the unconsolidated materials (overburden), and the depth to groundwater does not exceed the capacity of available excavating equipment.

Groundwater trenches also require operating personnel and routine maintenance. The system will have to be monitored to determine whether it is performing as designed.

5.1.3 Physical Barriers

Groundwater movement may also be controlled by means of physical barriers. Trenches excavated to a depth below the water table are backfilled with materials having very low permeability. Typically, a soil slurry is used to backfill the trench. The slurry is often composed of soil removed from the trench mixed with additives (Bentonite clay or Portland cement) to reduce its permeability. Slurry walls may have application where affected groundwater is moving off-site through the overburden or where significant volumes of groundwater enter the site through the overburden.

Physical barriers to groundwater movement may also be created by injecting materials such as Bentonite clays or Portland cement, under pressure, into the ground. The injected material, "grout", fills the pores and spaces through which groundwater normally moves. The use of injection grouting may have application in portions of the bedrock or in the overburden which is composed of more permeable materials (more highly fractured rock or coarser grained overburden).

In conjunction with pumping, the physical barriers may provide additional control over groundwater movement and reduce the amount of groundwater which must be pumped to establish control. Slurry walls and grout curtains would require no maintenance, but would require a monitoring program to measure their performance.

Special care must be taken to assure that there are no chemical constituents of the groundwater which would interfere with the reactions which establish the integrity of the physical barriers.

Therefore, laboratory testing and, perhaps, field testing of any proposed process would have to take place using actual groundwater and actual waste and soil samples from the site.

5.2 Treatment of Affected Groundwater

The concentrations of the regulated pollutants found in the affected groundwater are low. Those concentrations, however, may not be suitable for direct discharge to surface waters and, therefore, require treatment to remove the pollutants to an acceptable level for either use in facility processes, discharge, or reinjection.

Any groundwater which is used in NGK's manufacturing processes will be treated in the existing on-site treatment system prior to its discharge to the Laurel Run under the existing NPDES permit or its reuse within the facility.

Groundwater which is to be discharged to surface water must be treated to a level which is acceptable for the point at which the discharge occurs. For conceptual planning three possible points of discharge have been considered. They are the Laurel Run, the Schuylkill River via Riverview Park and the Schuylkill River via Rt 61 North. The discharge parameters will be established by PaDER and monitored by NGK.

All groundwater treatment systems have elements which are unique to the site for which they are intended. The combination of chemical and physical parameters which are present at the NGK site are no exception. Although many of the chemical parameters of the process wastes are similar to those associated with the affected groundwater, the treatment processes will be different. Therefore, it is essential that laboratory bench scale and pilot plant work be done using actual groundwater from the NGK site. It is only in this way that the performance of the full scale system can be confidently predicted.

5.2.1 Organic Compounds

The affected groundwater contains low levels of organic chemicals. Those concentrations, however, may not be suitable for direct discharge to surface waters and, therefore, require treatment to remove the pollutants to an acceptable level for either use in facility processes, discharge or reinjection.

Any groundwater which is used in NGK's manufacturing processes will be treated in the existing on-site treatment system prior to its discharge to the Laurel Run under the existing NPDES permit or its reuse within the facility.

Groundwater which is to be discharged to surface water must be treated to a level which is acceptable for the point at which the discharge occurs. The unit process or combination of processes selected will be chosen on the basis of the best technical and economic fit to the unique physical and chemical parameters present at the NGK site.

5.2.2 Inorganic Ions with Potential Production Interferences

If groundwater were to be used in NGK's production processes, the affected groundwater contains inorganic ions which have the potential to interfere with the

integrity of the products manufactured by NGK. These ions may or may not be regulated as pollutants but must be controlled to specific concentrations so as not to eliminate the opportunity to use and reuse the water in the manufacturing operations. The unit process or combination of processes selected will be chosen on the basis of the best technical and economic fit to the unique physical and chemical parameters present at the NGK site.

NGK's production engineering and technical staff, as well as their engineering consultants and legal counsel, have been included in all planning so that their advice and counsel were available to be considered in all decision making.

5.2.3 Inorganic Metals

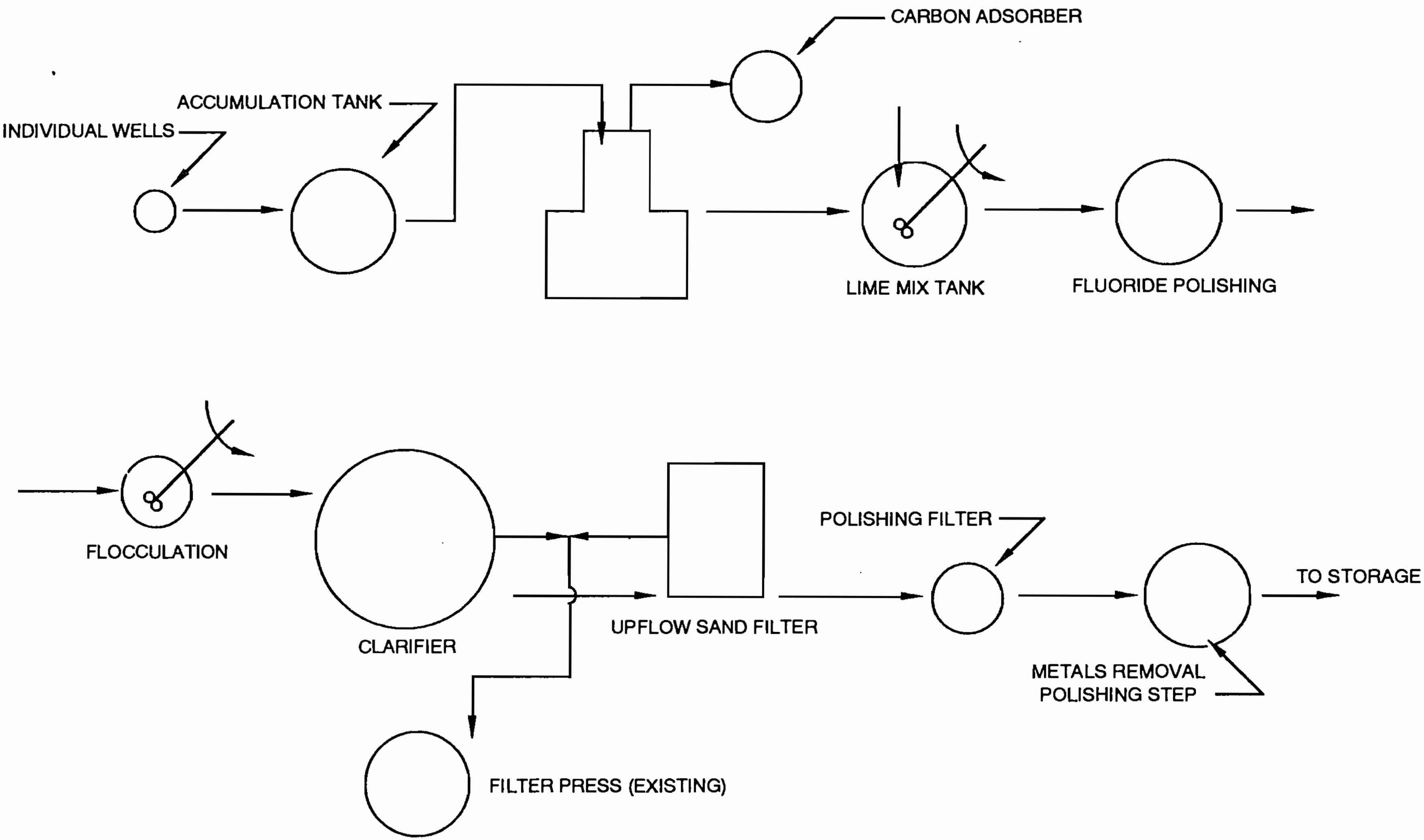
The affected groundwater contains, in low concentrations, inorganic metal ions which cannot, in those concentrations, be discharged to the environment. The offending ions include, among others, beryllium, cadmium, chromium and copper. There are a variety of effective methods for treating soluble metals. The unit process or combination of processes selected will be chosen on the basis of the best technical and economic fit to the unique physical and chemical parameters present at the NGK site.

The inorganic metals must be removed from the groundwater to very low concentrations to permit discharge of the groundwater from the NGK facility. The allowable concentrations and quantities will vary depending upon the discharge point. However, it is anticipated that the requirements will be very stringent.

A preliminary groundwater treatment schematic for removing organic and inorganic contaminants is shown of Figure 5.1. Suspended solids, in particular, will have to be very carefully controlled. This is because suspended solids, especially if they are soil particles, could carry detectable levels of metals adsorbed upon their surfaces. Because of the anticipated very low discharge limits, the soil particles must be removed.

5.3 Management of Treated Groundwater

There are a number of options available for the management of treated groundwater. They include discharge to the Laurel Run; the Schuylkill River; reinjection into the subsurface; or use within the manufacturing facility with subsequent reuse or discharge to the Laurel Run under the existing NPDES permit. The selection of the option or options depends upon the results of an analysis of all of the very complex factors which bear upon the site.



DUNN
DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

PRELIMINARY TREATMENT SCHEMATIC
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: No Scale	FIGURE NO.: 5-1

There are a number of uncertainties associated with a discharge to the Schuylkill River, each of which could be a limiting factor. These uncertainties include:

- Stream discharge criteria for the Schuylkill River
- Cost effectiveness of getting the discharged effluent to the Schuylkill River
- Availability and costs of obtaining necessary rights of way

6.0 EVALUATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES

In this Section, the technologies described in Sections 4 and 5 of this Report are evaluated with respect to the anticipated effectiveness and the ease and economy with which the technology can be implemented at the NGK facility.

In general, the technologies described in Sections 4 and 5 can be placed in two categories. The first category includes technologies designed to control the source of the problem; the buried waste materials such as red mud and waste water treatment sludges. The second category includes the technologies designed to recover and treat affected groundwater.

To select the corrective action program for the NGK facility, it will be necessary to assess the effect source controls will have upon groundwater quality. If it appears that groundwater quality will rapidly recover after the source materials are stringently controlled, then it may be unnecessary to develop a long-term program to pump and treat groundwater. Conversely, if it appears that it will be necessary to pump and treat groundwater indefinitely without regard to the degree of control applied to the source materials, then efforts expended at stringent source controls produce little benefit with respect to improving groundwater quality. As a part of this evaluation, data that are needed to better evaluate the applicability of each technology and the types of data needed to better predict the effects that source controls will have on the groundwater quality have been identified.

The following technology options for control of the source of the problems have been considered:

- No action
- Minimal/no action -- site fencing
- Minimal/no action -- deed restrictions
- Containment -- soil cover
- Multilayer cap
- Slurry wall
- Asphalt /Geotechnical cap
- Concrete/Geotechnical cap
- Run-on/run-off controls
- Excavation/on-site RCRA landfill
- Excavation/off-site RCRA landfill
- Vitrification
- Solidification/fixation
- In-situ soil flushing
- Vapor extraction

The following technology options for control and treatment of the affected groundwater have been considered:

- No action
- Deed restrictions
- Interceptor trenches
- Extraction wells
- Pump and treat
- Injection wells

Definitions:

Effectiveness is defined as the ability of the properly implemented technologies to meet the stated objectives of the corrective action program.

Reliability is defined as the ability of the properly implemented technologies to control and minimize the toxicity, mobility and volume of the wastes, affected soils and groundwater.

Implementability is defined as an assessment of the feasibility and ease with which the selected combination of technologies can be employed at the NGK facility and environmental operating permits can be obtained for them.

Protection (of human health and environment) is defined as the minimization or elimination of dangers to human or environmental health.

Cost (concept estimate) is defined as a cost estimate which has as its basis a preliminary concept of the equipment and processes which will be required to achieve the desired results. No detailed design information is available or used to arrive at a concept estimate of cost . Therefore, great care should be exercised in the use of such estimates for anything other than preliminary planning and engineering design and "order of magnitude" comparisons. More accurate cost estimates will be available after the completion of more detailed engineering and site specific process design.

Status is defined as the recommended state of the application of the technology. That is, is the technology recommended to be retained for further consideration, eliminated from consideration or rejected because of protection of human health and environment issues

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	Waste/Soils
Response Action	No action
Technology	No action
Description	No action - Site is allowed to follow a natural course of progression
Effectiveness	Risks are identified in risk assessment
Reliability	No effect plus or minus upon toxicity, mobility or volume
Implementability	Requires no implementation
Protection	Doesn't address protection issues
Cost (Concept Capital)	None
Cost (Annual O&M)	None
Present Worth(O&M)	None
Status	Retained for further consideration as required by RCRA

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	Waste/Soils
Response Action	Minimal/No action
Technology	Minimal/No action - Site fencing
Description	Site fencing - Often constructed of steel chain link with barbed wire and used to enclose a specified area. Restricts but does not totally eliminate site access. The existing site fencing is 8-foot high chain link, topped with barbed wire and with appropriate gates closing all openings. It fully surrounds the facility and access is controlled by security guards who monitor access 24 hours per day.
Effectiveness	Effective in reducing the risk of direct contact with affected soils and wastes.
Reliability	Reliability depends upon future maintenance and freedom from mechanical damage. Does not reduce toxicity, mobility or volume.
Implementability	Easily implemented, routinely used, readily available
Protection	There are no known protection issues. Does not have human health or environmental effects. Will not prevent migration of off-site water or air-borne particulates.
Cost (Concept Capital)	None
Cost (Annual O&M)	None
Present Worth(O&M)	None
Status	Existing fence encloses facility perimeter. Full time (24 hours per day) guards enforce exclusion from the site.

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	Waste/Soils
Response Action	Minimal/No action
Technology	Minimal/No action - Deed restrictions
Description	All deeds within the affected area would include restrictions upon the use of the property.
Effectiveness	Reduces some of the risk of direct contact with affected soils and wastes.
Reliability	No reduction in toxicity, mobility or volume.
Implementability	Easily implemented.
Protection	There are no known protection issues. Does not have human health or environmental effects.
Cost (Capital Concept)	Minimal
Cost (Annual O&M)	None
Present Worth(O&M)	None
Status	Retained for further consideration

Topic	**Waste/Soils**
Response Action	**Containment**
Technology	**Containment - Soil cover**
Description	Contain affected soil and wastes by covering with an additional layer of low permeability soil and revegetating a layer of top soil.
Effectiveness	Reduces the infiltration of water through affected soil and wastes, if sloped. Reduces the risk of direct contact with affected soils and wastes. Also reduces the mobility via air. Not fully effective in preventing infiltration. Subject to attack and disruption by burrowing animals. Does not satisfy RCRA requirements.
Reliability	Toxicity and volume are not controlled with the exception of airborne dusts. Some control of mobility is achieved by control of infiltration of water.
Implementability	Easily implemented with standard construction equipment and techniques.
Protection	There are no known extraordinary protection issues. The known protection issues are those associated with the construction and maintenance activities.
Cost (Capital Concept)	Currently in place
Cost (Annual O&M)	$2,500
Present Worth(O&M)	$28,145
Status	Rejected because of surface water infiltration through the affected soil/wastes

Topic	**Waste/Soils**
Response Action	**Containment**
Technology	**Multilayer cap**
Description	Contains disposal areas by covering with a layered cap consisting of soil, filter fabric, 50 mil synthetic membrane and synthetic drainage layer. The arrangement varies.
Effectiveness	The described cap is effective short-term and long-term in eliminating the infiltration of water into the affected soil and wastes. The method of construction provides several layers which should offer excellent long term protection against water penetration. Eliminates the risk of direct contact and airborne exposure to the soil and wastes. Reduces mobility. Meets RCRA and PA requirements..
Reliability	There is no change in the toxicity of the wastes/soils. Mobility of the contaminants is very much restricted because no liquid is present. Volume of the affected groundwater is reduced because it is prevented from coming into contact with the wastes/soils.
Implementability	Implementation requires careful engineering and construction and quality control. The capital costs associated with implementation are high. Special construction is required.
Protection	There are no known extraordinary protection issues. The known protection issues are those associated with the construction and maintenance activities.
Cost (Capital Concept)	PaDER Cap - $3,910,000 (Figure 4-2) RCRA Cap - $4,405,000 (Figure 4-1)
Cost (Annual O&M)	$97,500
Present Worth(O&M)	$1,097,650

Status	Retained for further consideration as an effective and accepted method for eliminating surface water infiltration through the affected soil/wastes.

Topic	**Waste/Soils**
Response Action	**Containment**
Technology	**Slurry wall**
Description	This method of containing waste/soils adds a slurry wall to the multilayer cap described previously. The purpose of the slurry wall is to prevent groundwater from outside of the capped area from horizontally or diagonally penetrating the soils/wastes.
Effectiveness	If the slurry walls are placed sufficiently deep and if the soil and geological conditions are uniform they can be effective in intercepting any penetrating water. However, the site in question exhibits karstic geology and is not uniform. The penetration of existing contamination is already quite deep so the effectiveness is questionable.
Reliability	The mobility will be reduced if the amount of water penetrating the waste is minimized. The longevity of the slurry walls in the presence of high concentrations of fluoride ion is questionable.
Implementability	The nature of karstic terrain and the depths of the wastes/affected soils makes the mechanical installation of effective slurry walls difficult.
Protection	There are the normal protection considerations associated with construction activities. In addition, if any of the excavation activity involves digging through wastes or affected soils, airborne metals could be released to the environment .
Cost (Capital Concept)	Not estimated because the technology is not appropriate.
Cost (Annual O&M)	Not calculated due to elimination
Present Worth(O&M)	Not calculated due to elimination

Status	Eliminated - not considered effective, unresolved protection issues

Topic	**Waste/Soils**
Response Action	**Containment**
Technology	**Asphalt /Geotechnical membrane cap**
Description	Contains affected soil and wastes by covering with an asphalt-topped cap which consists of an asphalt wearing surface, an asphalt base course, compacted stone, a filter fabric layer, 50 mil synthetic liner, and an intervening earth layer.
Effectiveness	The described cap is effective short-term and long-term in eliminating infiltration of water into the wastes and affected soils. The risk of direct contact with the affected soils and wastes is eliminated. Periodic maintenance and sealing is required to assure continued integrity because of sun and freeze-thaw damage. Substantial settling of the subsurface or the development of sinkholes may seriously impair the asphalt barrier. The synthetic liner does have substantial elasticity. An assessment of the bearing strength of the soil and wastes is required to determine maximum allowable loads. Can be damaged by solvents such as gasoline and diesel fuel.
Reliability	A reduction of mobility is achieved by minimizing the airborne dusts. The quality of the groundwater is improved because water is excluded from the wastes/soils. The volume of contaminants in the groundwater is reduced because it is not permitted to contact the wastes/soils.
Implementability	An asphalt /geotechnical membrane cap is relatively easy to implement although careful construction and excellent quality control are required to assure tightness and integrity.
Protection	There are no known extraordinary human or environmental protection issues. The known protection issues are related to construction and maintenance activities.

NGK CORRECTIVE ACTION TECHNOLOGIES

Cost (Capital Concept)	$2,415,000
Cost (Annual O&M)	$14,200
Present Worth(O&M)	$160,000
Status	Retained for consideration as an effective method for eliminating surface water infiltration through the affected soil/wastes when used in conjunction with a synthetic membrane.

Topic	**Waste/soils**
Response Action	**Containment**
Technology	**Concrete /Geotechnical membrane cap**
Description	Contains affected soil and wastes by covering with a concrete-topped cap which consists of a concrete wearing surface on a stone base, a filter fabric, a 50 mil synthetic liner, and intervening earth layers.
Effectiveness	The risk of direct contact with the affected soils and wastes is eliminated. Airborne spreading of dusts is also prevented. The described cap is effective in eliminating the infiltration of water into the wastes and affected soils. Periodic maintenance of the concrete surface and sealing of expansion joints is required to assure continued integrity of the cap. Substantial settling could seriously impair the integrity of the cap. An assessment of the bearing strength of the wastes/soils is required to determine the maximum allowable loads upon the surface.
Reliability	Reduces mobility of the contaminants and volume of the groundwater by preventing contact of water with the wastes/soils. Airborne spreading of the dusts is also prevented.
Implementability	The concrete cap is implementable using standard construction techniques coupled with flexible synthetic membrane construction techniques. Careful construction and sealing of all joints and interfaces is required to assure tightness and integrity.
Protection	There are no known extraordinary protection issues. The known protection issues are related to construction and maintenance activities.
Cost (Capital Concept)	$2,900,000
Cost (Annual O&M)	Not calculated due to rejection

Present Worth(O&M)	None - rejected
Status	Rejected as a site-wide measure due to potential for surface cracking and expansion joint separation. However, may be applicable to specific small areas. Multilayer cap performs required function more effectively

Topic	Waste/Soils
Response Action	Containment
Technology	Run-on /run-off controls
Description	Prevents surface water from entering the vicinity of the waste areas by means of interceptor swales. Allows run-off to be directed off the cap and away from the wastes and affected soils.
Effectiveness	Interceptor swales are effective in preventing run-on to the affected soils/wastes and in directing the run-off from the cap away from the affected soils/wastes. Periodic maintenance of the swales is required.
Reliability	Reduces mobility by preventing run-on and subsequent percolation through the wastes/soils.
Implementability	Implementable using standard construction techniques. Careful construction is required to assure complete drainage and elimination of ponding.
Protection	There are no known extraordinary human protection issues. The known protection issues are related to construction and maintenance activities.
Cost (Capital Concept)	$64,000
Cost (Annual O&M)	$500
Present Worth(O&M)	$5630
Status	Retained for consideration as an effective method for eliminating run-on to and controlling run-off from the capped waste and affected soils.

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	**Waste/Soils**
Response Action	**Removal and Disposal**
Technology	**Excavation/On-Site RCRA landfill**
Description	Removes the wastes and partially removes the affected soils from their current locations and places them in a lined, capped landfill . A cap, double liner and drain system are employed.
Effectiveness	Very effective in preventing water contact with the wastes/soils and in controlling airborne material dispersion. Human contact with the wastes/soils is also controlled and minimized. Periodic maintenance of the cap and drain system are required.
Reliability	The mobility of the contaminants is reduced substantially because contact with water and air are minimal. The quality of the groundwater is improved because contact with the wastes/soils is eliminated. The volume of affected groundwater is reduced because contact with the wastes/soils is eliminated.
Implementability	Specialized construction techniques and, experienced, skilled labor are required to correctly implement the design of a RCRA landfill. Quality assurance/quality control procedures are rigorous. Multiple, time consuming, steps are required. Monitoring requirements are extensive and expensive.
Protection	The usual human and environmental protection issues are associated with the construction of a RCRA landfill. An on-site landfill has the advantage that waste need not be hauled over public highways. However, the excavation of the wastes (1) will result in the release of airborne metals such as beryllium and (2) cannot result in the removal of all of the affected soil because of the nature of the geological terrain.

NGK CORRECTIVE ACTION TECHNOLOGIES

Cost (Capital Concept)	$7,360,000
Cost (Annual O&M)	Not calculated due to rejection
Present Worth(O&M)	Not calculated due to rejection
Status	Rejected-excessive risk to human and environmental protection and poor cost effectiveness.

Topic	**Waste/Soils**
Response Action	**Removal and Disposal**
Technology	**Excavation/Off-site RCRA landfill**
Description	Removes the wastes and partially removes the affected soils from their current locations and places them in a lined, capped off-site landfill to prevent all contact of surface and ground water.
Effectiveness	Very effective in preventing water contact with the wastes and in controlling airborne material dispersion. Human contact with the waste is also controlled and minimized.
Reliability	The mobility of the contaminants is reduced substantially because contact with water and air are minimal. The volume of wastes/soils at the NGK site will be reduced.
Implementability	Space must be purchased in a permitted, monitored RCRA landfill. Because no such landfills exist within Pennsylvania, substantial transportation costs will be incurred.
Protection	Common human and environmental protection issues are associated with the excavation, loading and transportation of the affected soil and wastes. However, the excavation of the wastes (1) will result in the release of airborne metals and (2) cannot result in the removal of all of the affected soil as well as the waste. There are also substantial "land ban" and long-term liability issues.
Cost (Capital Concept)	$44,850,000
Cost (Annual O&M)	$55,000
Present Worth(O&M)	$620,000
Status	Rejected- involves substantial unjustified cost for questionable environmental benefit. Excessive risk to human health and environmental protection.

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	**Waste/Soils**
Response Action	**Soil/Wastes treatment**
Technology	**Vitrification**
Description	Uses large amounts of electricity, applied through electrodes, to vitrify the silica present in the soil. Graphite is placed upon the soil surface to connect the electrodes . The heat generated from this system causes a melting that gradually works downward through the soil.
Effectiveness	Inorganics and some organics are trapped within the melted silicates that cool to form obsidian, strong dense glass. Other organics are destroyed in the process. Unproven in large scale applications at hazardous waste sites.
Reliability	Can be highly effective, under certain conditions, in small areas for reducing toxicity, mobility and volume of contaminants.
Implementability	May not function in karst terrain because of gross nonuniformities. Very expensive process which is better suited to small, well defined, areas which have a high silica content and contain very hazardous materials which justify the expense.
Protection	The area being processed must be isolated to prevent the entry of humans or animals. Off gases from the process may have to be collected and treated.
Cost (Capital Concept)	N/A
Cost (Annual O&M)	Not calculated due to elimination
Present Worth(O&M)	Not calculated due to elimination
Status	Eliminated. Site conditions are not conducive to the proper application of vitrification

Topic	**Waste/Soils**
Response Action	**Soils/wastes treatment**
Technology	**Ex-situ solidification/fixation**
Description	Consists of transforming excavated affected solids into a nonleachable form or creating an easy to handle material.
Effectiveness	Can effectively reduce the mobility of inorganics. May not be effective for soils containing VOCs. Pilot test required to evaluate reduction in mobility. Does not reduce the toxicity of contaminated material. Effectiveness may be impaired by the presence of high concentrations of fluoride ions in the soil or waste. For complete mixing, requires removal or disturbance of the soils/wastes and mixing with the other reactants to produce a solid.
Reliability	Toxicity is not reduced. Volume will be increased. Mobility will be substantially reduced. Reliability may be questionable because of the unknown effects of the fluoride ions present.
Implementability	The nature of the wastes may interfere with the solidification process. The underlying karst terrain and variability of the soil above it make excavation virtually impossible. The mixing operations will release airborne inorganic materials into the environment.
Protection	Questionable because of the large number of unknowns and the potential release of airborne inorganics.
Cost (Capital Concept)	$7,360,000
Cost (Annual O&M)	Not calculated due to elimination
Present Worth(O&M)	Not calculated due to elimination

Status	Eliminated-site not conducive to process
Note:	In-situ soil mixing and solidification was considered. It was rejected after weighing the above factors. The primary reason for rejection is that the site is not physically conducive to the process.

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	**Groundwater**
Response Action	**Minimal**
Technology	**No action**
Description	No action. Groundwater is allowed to follow a natural course of progression with periodic monitoring.
Effectiveness	Not effective
Reliability	Not reliable in reducing toxicity, mobility, or volume
Implementability	Requires no implementation
Protection	Doesn't address protection issues
Cost (Capital Concept)	None
Cost (Annual O&M)	None
Present Worth(O&M)	None
Status	Retain for further consideration as required by RCRA

Topic	**Groundwater**
Response Action	**Minimal/No action**
Technology	**Deed restrictions**
Description	All deeds within the affected area would include restrictions upon the use of the property.
Effectiveness	Reduces some of the risk of direct contact with and use of the affected groundwater.
Reliability	No reduction in toxicity, mobility, or volume.
Implementability	Easily implemented. Enforcement may be difficult.
Protection	There are no known protection issues. Does not have human health or environmental effects unless future enforcement is lax.
Cost (Capital Concept)	None
Cost (Annual O&M)	None
Present Worth(O&M)	None
Status	Retained for future consideration only in conjunction with other measures

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	**Groundwater**
Response Action	**Containment**
Technology	**Interceptor Trenches**
Description	Interceptor trenches are dug into the soil, a collection system is built into the trench, and accumulated affected water is pumped to a recovery system.
Effectiveness	Interceptor trenches can be very effective if the soil conditions, the site geology and the nature of the contaminants are correct. Control of mobility and volume leaving the site can be good.
Reliability	No effect upon toxicity. Mobility is reduced because the affected water is intercepted and removed. Reliability can be adversely affected by the soil and geological conditions on the site.
Implementability	Fairly easy to implement using standard construction techniques under favorable soil and geological conditions. It is notably difficult to implement where there is no "free product", where the contaminants are dilute, in karst terrain, and where the soil is clayey.
Protection	There are the usual protection issues associated with excavation and construction. If the trenches cut through affected soils or wastes, there is a potential problem with human contact or dispersal of airborne toxics.
Cost (Capital Concept)	None calculated - rejected
Cost (Annual O&M)	Not calculated due to rejection
Present Worth(O&M)	Not calculated due to rejection
Status	Rejected for protection of human and environmental health and site specific reasons

NGK CORRECTIVE ACTION TECHNOLOGIES

Topic	Groundwater
Response Action	Containment
Technology	Extraction wells
Description	Used to draw affected groundwater from subsurface for treatment and disposal
Effectiveness	Effective short and long term in preventing further off-site migration of the affected groundwater. Depends upon the skill of the computer modeler and the accuracy of the field data with which the modeler works.
Reliability	Does not, in and of itself, reduce toxicity. However, it does make groundwater available for treatment. Reduces mobility by restricting the movement of groundwater. Does not affect volume.
Implementability	Requires expert placement, development, and operation of the wells. Implementable with standard drilling and well development techniques, pumping equipment, piping, and valves.
Protection	Construction safety requires RCRA monitoring and protection. Muds, soils and water from the drilling operations will have to be collected, contained, and analyzed. If contaminated, the materials will be treated at a properly permitted facility.
Cost (Capital Concept)	$133,000
Cost (Annual O&M)	$14,000
Present Worth(O&M)	$157,600
Status	Retained for further consideration

Topic	**Groundwater**
Response Action	**Pump and Treat/Discharge**
Technology	**Discharge to surface water**
Description	Discharge of the pumped groundwater to surface water after treatment to regulatory standards
Effectiveness	Discharge of treated water to surface water is a very effective means of disposal. Extensive testing of the proposed process is required. The permitting process is long and involved.
Reliability	Toxicity, mobility, and volume are all reduced or eliminated by treating for discharge to surface water. The reliability of the treatment process is highly dependent upon laboratory and pilot scale process development work and its engineering implementation .
Implementability	It will be very difficult to consistently implement the treatment process because of the expected extraordinarily low expected discharge limits. The treatment process (Figure 5-1) is implementable using unit processes which must be selectively modified based upon the information obtained during the laboratory bench and pilot scale testing. The treated groundwater will have to be discharged to surface water at a location accessible to NGK and acceptable to the regulatory agencies. Three possible locations for the discharge were considered for the purpose of establishing technical feasibility and conceptual costs. They were Laurel Run, the Schuylkill River via Riverview Park, and the Schuylkill River via Rt 61 North. NGK will evaluate the extent to which the treated water may be used in the manufacturing process. It may be necessary to discharge all or a portion of the treated groundwater to surface water. This will done in accordance with any appropriate permit condtions. Internal piping and water storage changes will be required.

Protection	Human and environmental protection are served by removing virtually all of the contaminants from the groundwater pumped through the system. The contaminants are captured or immobilized to remove them from the environment. Solid wastes are generated and must be disposed of properly.
Cost (Capital Concept)	\$460,000- \$1,200,000
Cost (Annual O&M)	\$132,000 - \$142,500
Present Worth(O&M)	\$1,486,000 - \$1,604,500
Status	Retained for consideration

Topic	**Groundwater**
Response Action	**Pump and Treat/Injection**
Technology	**Injection wells**
Description	Treated groundwater is injected into wells upstream of the groundwater extraction wells. Extraction wells will help control local groundwater table elevations to restrict the movement of affected groundwater off-site.
Effectiveness	Under appropriate conditions, the injection wells can be effective. Uniform geological and soil conditions are best for effective use of injection wells. Karst terrain and clayey soils are difficult conditions for the operation of injection wells.
Reliability	Injection wells in the shallow aquifer allow for the control of mobility. However, there is, in karst terrain, no effective way to control the direction in which the injected treated water goes. Toxicity is influenced only in that clean water displaces affected water and flushes affected wastes/soils.
Implementability	The soils and geology of the area makes injection of all of the pumped and treated groundwater extremely difficult.
Protection	There are no known unusual problems associated with human or environmental protection.
Cost (Capital Concept)	$115,000
Cost (O&M)	Not calculated due to elimination
Present Worth	Not calculated due to elimination
Status	Eliminated -- inappropriate technology for NGK site

Topic	**Waste/Soils**
Response Action	**Treatment**
Technology	**In-situ Soil Flushing**
Description	In-situ soil flushing consists of the injection of clean treated or fresh water into the upper levels of the vadose zone. If the soil characteristics and the chemical and physical nature of the contaminants are appropriate, the water will be drawn through the soil, extracting the contaminants. The flushing water is then withdrawn and treated to remove the contaminants prior to the reuse of the water.
Effectiveness	If all conditions are conducive to in-situ soil flushing, i.e., the soil is permeable, the site is uniform, the contaminants are water soluble and the water can be recovered in sufficient volume, in-situ soil flushing can work well.
Reliability	The mobility of the contaminants is increased to allow for their removal. The toxicity of the soils will be reduced and ultimately minimized. The volume will be increased to allow for the removal of the contaminants.
Implementability	The successful implementation of in-situ soils flushing is highly problematical at the NGK site because of the highly complex and variable nature of the vadose zone. Highly irregular bedrock; variations in shape, including dense clay; and the presence of detrital material all add to the complexity and variability. These conditions make the planning and design of an in-situ soil flushing system extremely difficult. Even if the design and installation impediments could be overcome, there is no assurance that the system would function properly.
Protection	There are the normal human and environmental protection issues associated with construction activities. Operating issues would relate to the contaminants being removed and treated. All

	VOCs would be captured and metals treated for removal. All solids and construction related water would be captured, tested and, if necessary, treated at appropriate permitted facilities.
Cost (Capital Concept)	Not estimated because the technology is not appropriate
Cost (Annual O&M)	Not calculated due to elimination
Present Worth (O&M)	Not calculated due to elimination
Status	Eliminated - not appropriate to NGK site

Topic	**Waste/Soils**
Response Action	**Treatment**
Technology	**Vapor Extraction**
Description	This method of treating waste/soils involves the removal of volatile organic compounds from the vadose zone through vacuum assisted volatilization. VOCs with appropriate characteristics, permeable soils, well defined areas of contamination and sufficient concentrations of VOCs have a substantial positive effect.
Effectiveness	If all conditions are conducive to vapor extraction (VE), i.e., the chemical and physical characteristics of the VOCs of concern are appropriate, the soil is sufficiently permeable, the areas of contamination are well defined and there is a sufficient concentration of VOCs, the process works well at a reasonable cost.
Reliability	The mobility of the VOCs not adsorbed onto the soil will be reduced and ultimately minimized. The toxicity of the soils will be reduced and ultimately minimized. There will be no apparent effect upon volume of the wastes/soils.
Implementability	The successful implementation of vapor extraction (VE) is highly problematical at the NGK site because of the highly complex and variable nature of the vadose zone. Different areas within the NGK site have one or more soil and rock conditions which make planning and designing a VE system very difficult and expensive. Further, because of the extreme variability of the site, there is no assurance that a VE system would function properly. VE is, therefore, <u>not</u> recommended.
Protection	There are the normal human and environmental protection issues associated with construction activities. Construction and operating issues would relate to the VOCs being removed from the wastes/soils; their handling and disposition. All VOCs would be appropriately captured, tested and,

	if necessary, treated at appropriate permitted facilities.
Cost (Capital Concept)	Not estimated because the technology is not appropriate
Cost (Annual O&M)	Not calculated due to elimination
Present Worth (O&M)	Not calculated due to elimination
Status	Eliminated - not conducive to NGK site

7.0 JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S)

7.1 Description of Selected Corrective Measures

It is recommended that the corrective measures proceed in phases so the maximum benefit can be derived from the implementation of each phase. The first phase is intended to provide control of the source(s) which appear to be affecting the groundwater beneath the NGK site and to prevent the direct contact with the wastes and/or affected soils. It is considered especially important to prevent the intrusion of stormwater and precipitation into the wastes. The design and implementation of the second phase will proceed during the implementation of the first phase. The second phase will also rely on information generated in the laboratory and through field pilot tests. The schedule for implementing the corrective action program at NGK is given in Figure 7-1 - RCRA Corrective Action Implementation Schedule. The ultimate point of treated groundwater discharge will be determined in the second phase.

The combination of corrective measures selected to best meet the first phase environmental needs of the NGK site follows:

(1) Maintain the existing fence which encloses the entire facility to enclose the affected area and prevent unauthorized entry. A 24-hour per day security force is employed to prevent unauthorized entry;

(2) Build an interceptor swale around the following locations to prevent storm water run-on onto the affected areas:

- Pond 2;
- Pond 3;
- Southeast Red Mud & Filter Cake Disposal Area; and
- Southwest Red Mud & Lime Sludge Disposal Area;

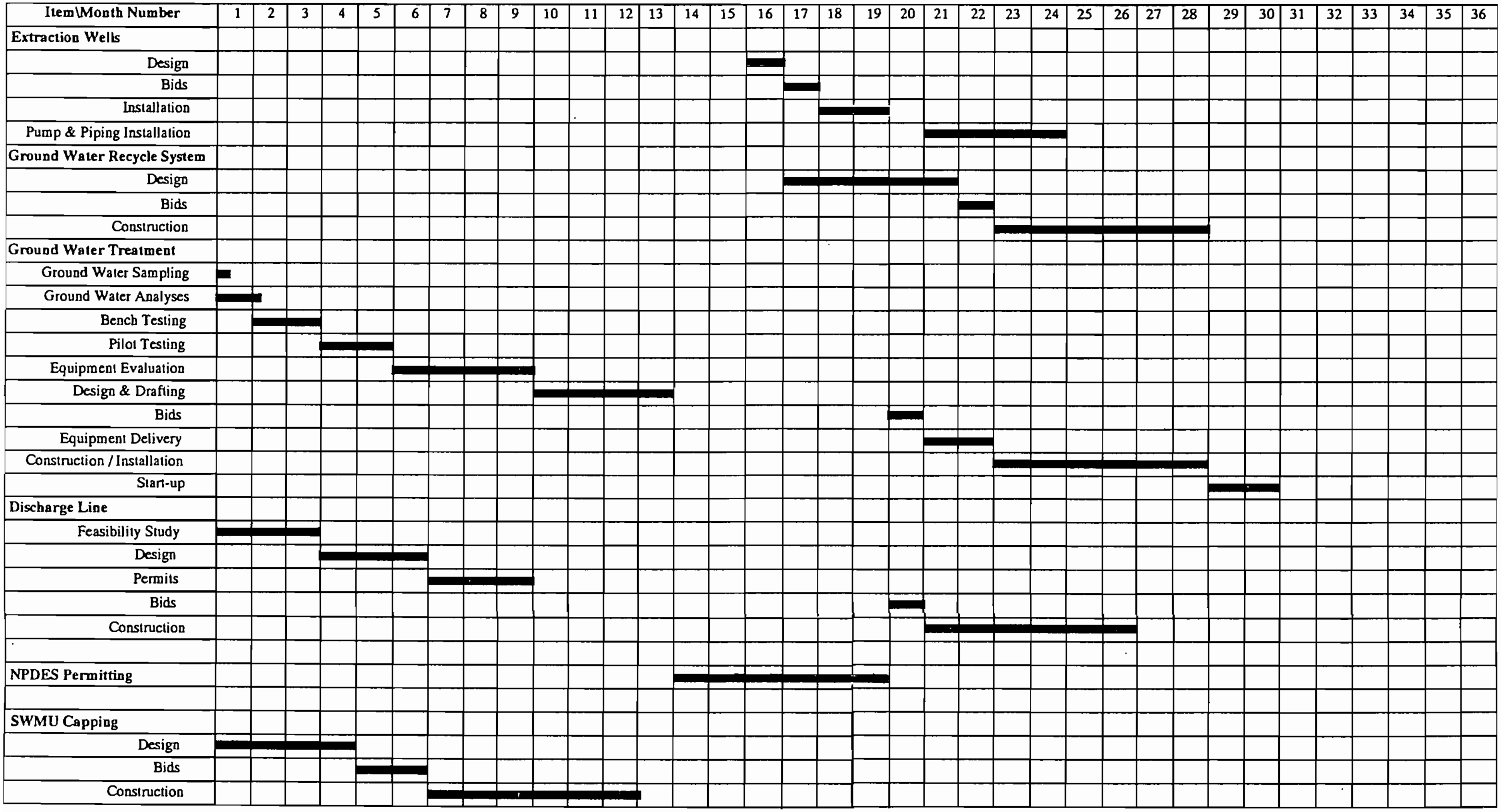
(3) Address the SWMUs at the site as follows:

Retention Basin - NGK's office parking lot is in-place over this former disposal area. This parking lot is a well maintained macadam surface area with storm sewers in place to divert storm water run-off. Modelling demonstrates that no further action is required at this location;

Pond #1 - As shown on Figure 7-2, cap this area with an impermeable asphalt - geotechnical membrane cap to prevent the intrusion of precipitation through the affected soils and wastes which will be left in place and undisturbed;

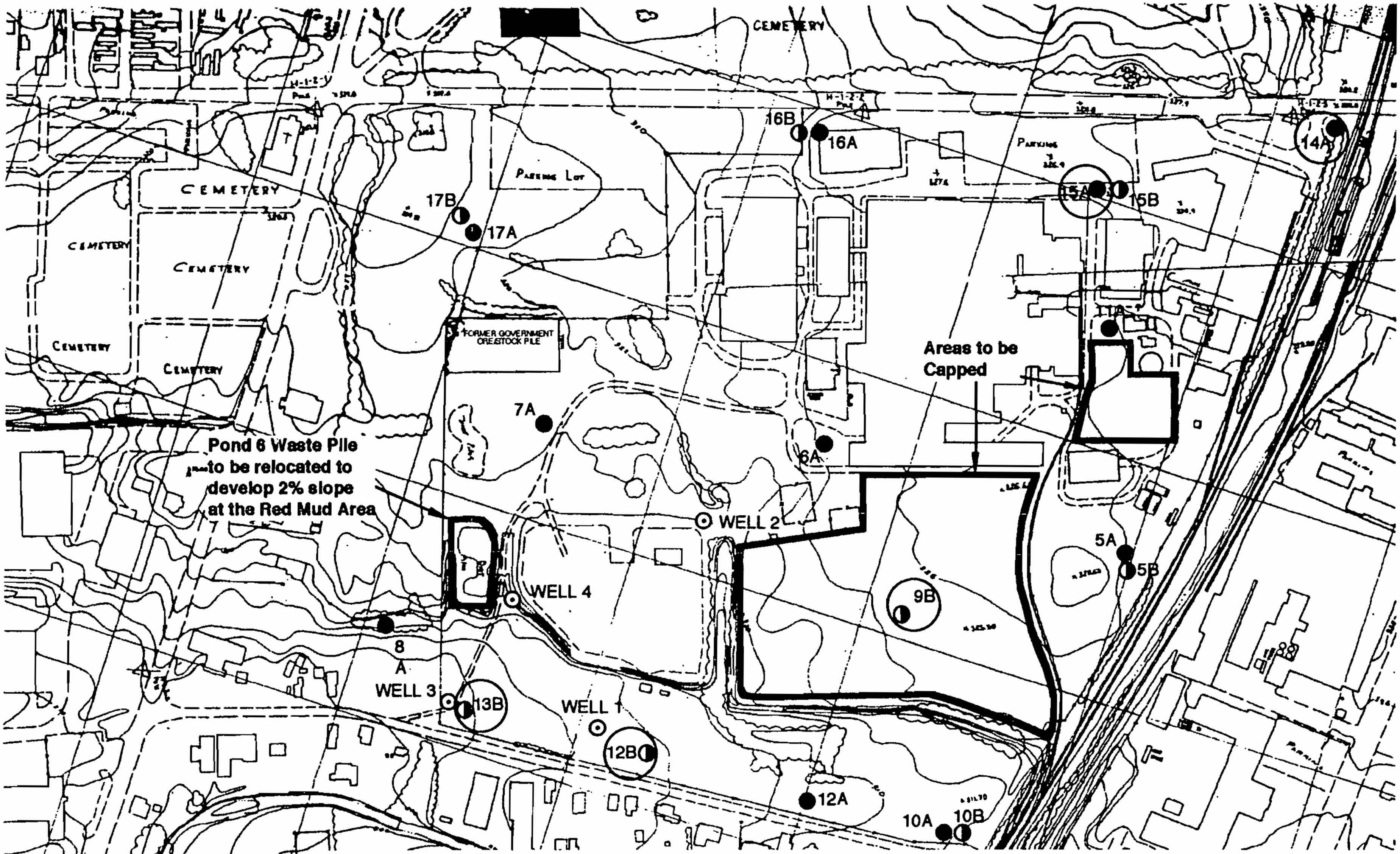
Figure 7-1

NGK Metals Corporation
Muhlenberg Township, Berks County, Pennsylvania
RCRA Corrective Action Implementation Schedule



Notes: Schedule to start upon issuance of a ROD.

Schedule may require modification due to time of year and construction seasons.



LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- LANDFILL WELL
- 13B PUMPING WELL

N

DUNN

DUNN CORPORATION
Engineers, Geologists, Environmental Scientists
2 Market Plaza Way, Mechanicsburg, PA 17055
Phone: 717/795-8001 Fax: 717/795-8280

PROPOSED CORRECTIVE ACTION
RCRA CORRECTIVE MEASURES STUDY
NGK METALS CORPORATION
READING, PENNSYLVANIA

PROJECT NO.: 30943-05756	DATE: FEBRUARY 1992	SCALE: 1"=300' Approximate	FIGURE NO.: 7-2

30943-05756

Pond #2, The Southeast Red Mud & Filter Cake Disposal Area, And The Southwest Red Mud & Lime Sludge Disposal Area (Red Mud Area) - Cap these areas with a single impermeable asphalt - geotechnical membrane cap to prevent the intrusion of precipitation through the affected soils and wastes which will be left in place and undisturbed, as shown on Figure 7-2;

Pond #6 Waste Pile - As shown on Figure 7-2, relocate this soil/waste pile to the Red Mud Area and use it to help develop a 2% slope beneath the cover to promote run-off in that area; and

Disposal Area Drain Field - No waste materials were disposed in this area. However, surface contamination exists in this area as a result of surface water run-off from the above disposal areas. Modelling demonstrates that an impervious cap is not required for this area. Cover this area with 6 to 12 inches of clean soil such as loam and vegetate the area to prevent wind dispersion and direct contact with affected soils;

(4) Analytical monitoring will be employed to track the progress of the control measures of Phase 1 and help determine how the technologies will be implemented in Phase 2.

The combination of corrective measures selected to best meet the second phase environmental needs of the NGK site follows:

(1) Evaluate, on a continuing basis, the impact of Phase 1 activities on groundwater movement and groundwater quality at the NGK site.

(2) Install extraction wells to help control local groundwater table elevations to restrict the movement of affected groundwater off-site.

(3) Pump the recovered water to an on-site treatment facility where it can be processed to remove the materials which make it inappropriate for use within the production facility or for discharge to the environment;

(4) Use or manage the treated groundwater in an appropriate and environmentally acceptable manner. Environmental operating permits appropriate to the selected method of managing the groundwater will be secured prior to discharge.

Further leaching of the water soluble and organic contaminants contained in the wastes will be prevented. Eventually, as the groundwater is withdrawn and treated, the aquifer will be flushed with unaffected water and be restored. The process of restoration of the groundwater will probably be long-term.

7.2 Basis for Selection

The selected combination of corrective measures is being recommended on the basis of an optimization of the integrated factors of anticipated effectiveness, reliability, implementability, protection and cost-effectiveness associated with the combination.

Each potential combination was first examined with respect to human and environmental protection. If it was apparent that human or environmental protection would or could be unacceptably compromised by the selection of a site corrective measures system it was eliminated from consideration. Three major areas of human or environmental protection concern were considered: (1) Groundwater, (2) Waste/Soils, and (3) Construction/Transportation.

Those combinations which passed the initial human and environmental protection screening were then examined with respect to the other enumerated factors, with effectiveness on the NGK site being a key screening factor. Obviously, in addition to being effective, the selected combination also had to be reliable, implementable and cost effective.

7.2.1 Technical

7.2.1.1 Effectiveness

Effectiveness is defined as the ability of the properly implemented technologies to meet the stated objectives of the corrective action program. The effectiveness of the selected combination of corrective measures is expected to be excellent:

(1) Human contact with the wastes/soils will be minimized by maintaining the fencing surrounding the affected area and by installing an impermeable cap.

(2) The potential for dispersion of airborne metals will be minimized by allowing the wastes in the disposal areas to remain undisturbed prior to capping.

(3) Interceptor swales will prevent the run-on of stormwater onto the described affected areas and its subsequent percolation through the waste disposal areas.

(4) Extraction wells will help control local groundwater table elevations to restrict the movement of affected groundwater off-site.

(5) The groundwater will be treated to an appropriate level to allow its reuse or discharge to the environment.

7.2.1.2 Reliability

Reliability is defined as the ability of the properly implemented technologies to control and minimize the toxicity, mobility, and volume of the wastes and affected soils and groundwater. The reliability of the selected combination of corrective measures is expected to be excellent:

(1) The asphalt geotechnical cap will reduce the mobility of the contaminants present in the wastes and the soil by preventing the intrusion of and attendant leaching by precipitation;

(2) The asphalt geotechnical cap will prevent the dispersion (mobility) of airborne metals by wind erosion;

(3) The interceptor swales will reduce the mobility of the contaminants present in the wastes/soils by reducing the amount of surface water run-on available for percolation through to the groundwater;

(4) The extraction wells control the mobility of affected groundwater at the facility

(5) The technologies which will be employed to treat the affected groundwater will control and minimize its toxicity. The materials which are removed from the groundwater through treatment will be handled as solids and disposed of in permitted facilities. They will be managed so that they do not reenter the environment;

(6) The total volume of materials, including water considered as waste, which must be handled as waste will decrease as a result of the concentrating effects of the treatment process.

(7) The series of processes by which the groundwater is treated allows the observation of progress in the restoration of groundwater. Analytical procedures appropriate to the detection and quantification of the contaminants of interest are available. When the contaminant level stabilizes and remains stable for eight successive sampling periods, the remediation process will conclude. Stability is defined as the point at which the values of eight successive quarterly analyses for Be, Cd, Cr and Cu, 1,1 DCE and TCE fall within + or - 20% of the average of the four values.

7.2.1.3 Implementability

Implementability is defined as an assessment of the feasibility and ease with which the selected combination of technologies can be employed at the NGK facility. It is expected that the implementability will be excellent:

(1) There is adequate room at the NGK facility to install and operate the technologies;

(2) The technologies are compatible with the surrounding areas and will not have an adverse impact upon them;

(3) The technologies will not adversely impact plant operations;

(4) The selected combination of technologies minimizes the number and variety of permits required to accomplish the stated objectives of the corrective action program;

(5) The resources to implement the selected technologies are readily available to NGK;

(6) Experienced, qualified contractors are available within reasonable distance of the site to assure competitive bids; and

(7) The technologies will have minimum impact upon the future beneficial use and control of the NGK facility.

7.2.1.4 Protection (of human health and the environment)

Protection is defined as the minimization or elimination of dangers to human or environmental health. It is expected that the protective capacity of the proposed combination of technologies will be excellent:

(1) Other than those associated with construction related activities, there are no known human or environmental protection issues related to the construction of the interceptor swales, or the construction of the impermeable cap;

(2) The exposure of humans (on-site or off-site) or the environment to wastes or affected soils and groundwater will be minimized through the use of the selected technologies.

DUNN CORPORATION

Engineers. Geologists. Environmental Scientists
2 Market Plaza Way
Mechanicsburg, Pennsylvania 17055
Tel 717 795-8001
Fax 717 795-8280

RCRA CORRECTIVE MEASURES STUDY

THREE DIMENSIONAL FINITE-DIFFERENCE GROUNDWATER FLOW MODEL

NGK METALS CORPORATION READING FACILITY

Prepared for:

NGK METALS CORPORATION
READING FACILITY
READING, PENNSYLVANIA 19612

Prepared by:

DUNN CORPORATION
2 MARKET PLAZA WAY
MECHANICSBURG, PENNSYLVANIA 17055

Date:

FEBRUARY 21, 1992

TABLE OF CONTENTS

			PAGE
LIST OF FIGURES			iii
1.0	PREDICTIVE ANALYSIS		1-1
	1.1	The Numerical Model	1-1
	1.2	The Conceptual Model	1-3
	1.3	Data Requirements, Grid Detail, and Boundary Conditions	1-3
	1.4	Model Limitations	1-4
	1.5	Results of Modeling the Existing Groundwater Flow System	1-6
2.0	DEWATERING ANALYSIS		2-1
	2.1	General	2-1
	2.2	Dewatering Simulation Results	2-1

1	Grid Configuration of Model Area	1-2
2	Simulated Groundwater Elevation Map	1-8
3	Regional Groundwater Elevation Map	1-9
4	Simulated Groundwater Elevation Map - Well MW-9A Pumping at 20 gpm	1-10
5	Simulated Groundwater Elevation Map - Well MW-15A Pumping at 7 gpm	1-11
6	Simulated Grondwater Elevation Map - Well MW-9A Pumping at 20 gpm Well MW-8A Pumping at 15 gpm Well MW-12B Pumping at 15 gpm Well MW13B Pumping at 15 gpm Well MW-16A Pumping at 7 gpm Well MW-15A Pumping at 7 gpm Well MW-14A Pumping at 7 gpm	2-2

1.0 PREDICTIVE ANALYSIS

1.1 The Numerical Model

A numerical groundwater model was used to help evaluate the hydraulic behavior of the saturated unconsolidated and consolidated aquifer materials in the vicinity of NGK and to provide a tool to evaluate the proposed groundwater recovery system. Numerical modeling was deemed necessary because of the complexity of the groundwater flow system within the interlayered formations and the inadequacy of simpler mathematical analyses that only accommodate homogeneous and isotropic (isotropic - having physical properties that are the same regardless of the direction of measurement) aquifer conditions (such as classical pumping test analyses described by Kruseman and DeRidder, (1983), or dewatering analyses described by Powers, (1981)).

The model used was the U.S. Geological Survey (U.S.G.S.) three-dimensional (3D), finite-difference groundwater flow model (McDonald and Harbaugh, (1984)). The model solves the three-dimensional groundwater flow equation which is a form of the continuity equation (principle of conservation of mass). The interested reader is referred to the model documentation (Trescott et. al, 1976) or groundwater texts such as Bear (1979) for the theoretical equations which describe groundwater flow.

The three-dimensional model was first used to simulate the existing groundwater flow conditions within the "drainage basin" which encompasses the NGK site. Though a three-dimensional simplification, this modeling provided keen insight regarding aquifer properties as well as the current groundwater flow patterns.

Like most aquifer systems, the unconsolidated (e.g. soils) and consolidated (e.g. bedrock) aquifer materials have variable properties and complex boundary conditions. Due to the interlayering within the unconsolidated materials and the fractured and solutioned nature of the carbonate formations, an exact mathematical analysis describing the groundwater flow cannot be obtained directly. However, utilizing a porous media approach, approximations using numerical methods can be made to help evaluate the groundwater flow system.

The numerical method used involves the substitution of finite-difference approximations for the partial derivatives in the flow equation for porous media. To enable this approach, the area of interest is subdivided into a number of smaller sub-areas in which the aquifer properties are assumed uniform.

In the model, a variably spaced finite-difference grid (see Figure 1) was used to subdivide the modeled area into rectangular blocks (66 columns and 60 rows for this model). The point at the center of each block is called a node and nodes are located by the (i,j) indices. The hydraulic head at a given node is assumed to be the average head over the area of the block. Likewise, input data, such as aquifer thickness, are also assumed to be constant over the area of the block.

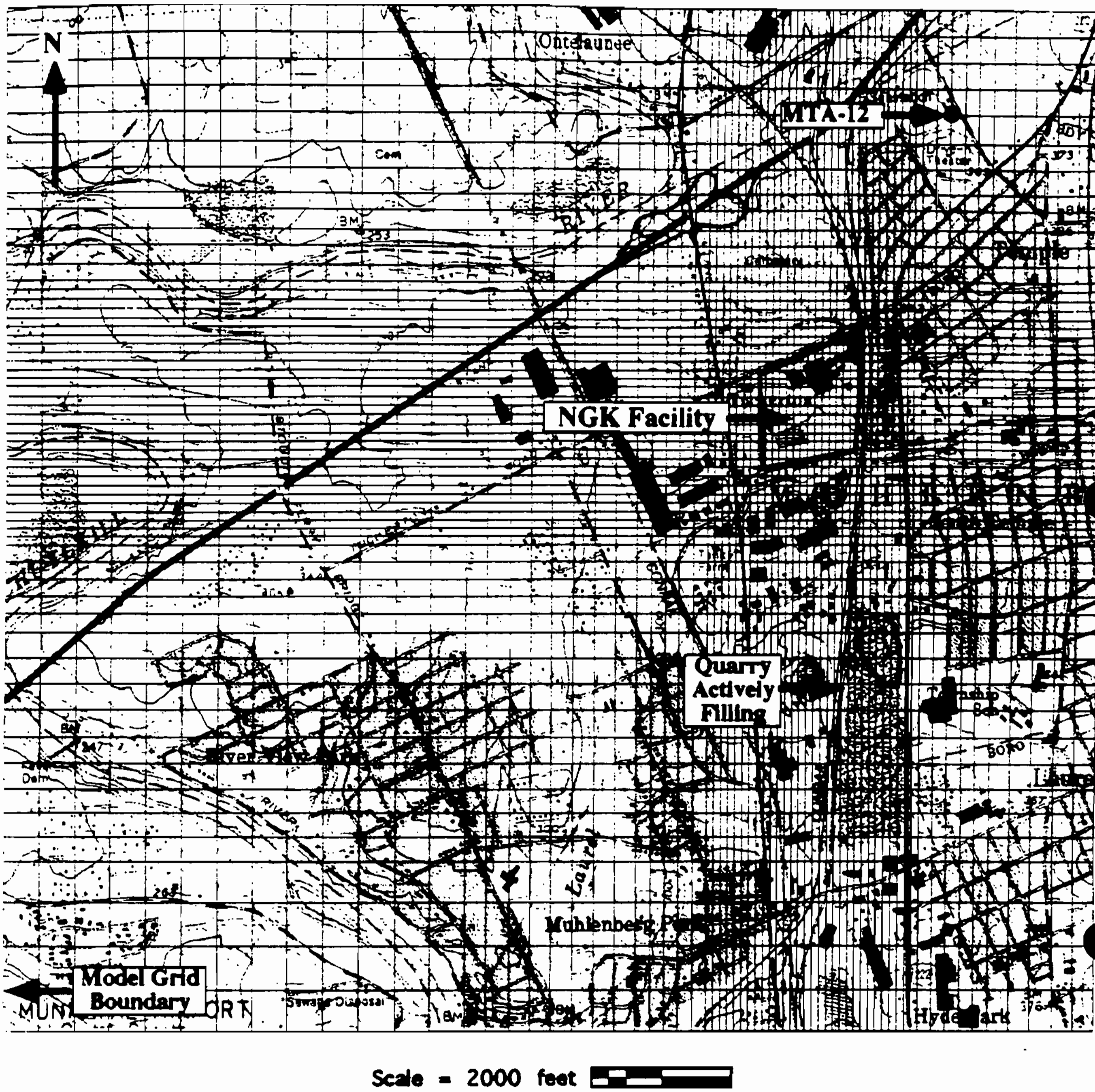


Figure 1
Grid Configuration of Model Area

1.2 The Conceptual Model

System conceptualization involves organizing available information on the hydrogeology into an internally consistent framework. This framework is the backbone of the conceptual model that qualitatively describes the behavior of the hydrogeologic groundwater system. The conceptualization is then translated from physical and qualitative terms into mathematical terms such as boundary conditions, aquifer thickness, hydraulic conductivity, storativity, and recharge rates.

Much of the conceptualization has been presented in the discussion on the hydrogeologic setting. Some specific simplifying assumptions inherent with the conceptualization are as follows:

1. The unconsolidated and consolidated aquifer materials can be represented as unconfined aquifers having variable permeabilities.

2. The subsurface flow system is bounded by a flux boundary in three directions. The eastern, southern and northern zero flux boundaries were established at sufficient distances and were assumed to be analogous to hydraulic divides. The western boundary corresponds with a major hydraulic divide (Schuylkill River) which is a groundwater divide.

3. A steady-state three-dimensional porous media aquifer analysis with recharge and vertical leakage to or from surface streams is sufficient to evaluate the hydraulic behavior of the unconsolidated and consolidated aquifer materials, and the effect of the proposed groundwater withdrawal system.

4. The hydraulic properties of the aquifer materials are non-homogeneous.

5. Water in the unconsolidated and consolidated aquifer materials in the vicinity of NGK is derived from precipitation within the drainage basin and leakage from Laurel Run.

1.3 Data Requirements, Grid Detail, and Boundary Conditions

The model requires both numerical and hydrogeologic information in order to simulate groundwater flow. A two-layer 66 x 60 rectangular grid with variable nodal spacing was used to subdivide the drainage basin and give the greatest detail in the vicinity of NGK and in the vicinity of pumping test wells and existing streams. The model, therefore, consists of 7920 grid blocks and nodes. Specific data are required for each node as input to the model. The input data arrays used for the simulations were as follows:

1. bottom elevation of the first and second layer;

2. top elevation of the second layer;

3. location of Laurel Run and an estimated value of recharge to the subsurface from the stream;

4. location of the river and the elevation of the free water surface;

5. aquifer hydraulic properties (i.e., specific yield and vertical and horizontal hydraulic conductivity);

6. evapotranspiration/recharge rates; and,

7. grid spacing in the x and y direction.

The 66 x 60 finite difference grid was designed with the grid columns oriented parallel to east to west and north to south. The model grid extends across a large portion of the drainage basin. The smallest grid blocks are spaced 100 feet and the largest are 500 feet. The grid blocks west of the river were set inactive because the river acts as a groundwater divide.

The data input used in the model were taken from literature and prior DUNN RCRA Facility Investigation reports, and adjusted when necessary. Reasonable adjustments to hydraulic conductivity values, infiltration, etc. are based upon understanding actual hydrogeologic systems. Through initial calibration, it was determined that the distribution of hydraulic conductivity (K) was not uniform across the drainage basin, because the simulations did not agree with measured water levels. Thus, for most simulations, the hydrogeologic properties were non-homogeneous. Generally the hydraulic conductivity values derived from the pumping and slug test results were used in the model. A non-homogeneous groundwater recharge (R) rate was used (a greater recharge rate was used to simulate Laurel Run).

1.4 Model Limitations

Any model is a simplification of a real system and thus is limited to some degree in its representation of the real system. It is appropriate to acknowledge and discuss model limitations to ensure they are taken into account when interpreting model results. Limitations are also described to help the reader interpret and understand model results. In no way do these limitations undermine the usefulness of the model. A model attempts to mimic reality but for most applications, an exact match to observed conditions is not achievable; nor is it reasonable (in terms of costs and time) to attempt to achieve an exact match. Thus, limitations are presented to guard against misinterpretation of model results.

Limitations of the three-dimensional model include:

1. possible inaccuracies in the system conceptualization, such as boundary conditions, physical shape/extent of the hydrogeologic units, hydraulic properties, etc.;

2. insufficient or inadequate data, especially groundwater levels, general geology, and aquifer properties outside the NGK property; and,

3. the inherent mathematical inaccuracies associated with the numerical solution scheme (Strongly Implicit Procedure – SIP) used by the U.S.G.S. three-dimensional flow model and the finite precision of computers.

The limitations of the conceptual model involve the dimensionality of the model, the boundaries of the aquifer, and the use of a porous media approach in a fracture and solution channel dominated flow system. This simplification neglects these flow components in the aquifer. However, the 3D analysis provides a reasonable approximation to the existing flow system.

The modeled aquifer boundaries may not be analogous to true aquifer boundaries. This is because it is uncertain whether the surface topography and drainage actually exert hydraulic boundary effects (i.e., no flow groundwater divides).

The model solves for groundwater flow in a porous media, not a fractured media. Thus, the discrete flow within fractures and solution cavities is not simulated which could lead to inaccuracy. However, analytical techniques for the analysis of flow through fractured media are not generally available. Also, with the appropriate grid design, a reasonable approximation of the hydraulic response of a fracture media can be made using the porous media approach.

The limitations, due to data deficiencies, are closely associated with the system conceptualization errors since observed data essentially dictate the conceptualization. Without observed hydrogeologic data, the hydraulic behavior of the aquifer must be inferred which can lead to inaccuracy. As for most subsurface systems, data deficiencies are associated with this model particularly outside the NGK property boundaries. Data on geology, and aquifer properties are uncertain. Thus, data collected at the site were used for the majority of the drainage basin. Inherent in this is the non-homogeneity of the aquifer properties across the drainage basin, particularly hydraulic conductivity. An actual pattern or mapping of this non-homogeneity is not available.

There are also limitations associated with the numerical solution procedure. Finite difference techniques are subject to two major types of error. The first is the error due to replacing the continuous differential equations describing groundwater flow by a set of finite difference approximations. The exact solution of the algebraic equations differs somewhat from the solution of the original differential equations.

The resultant errors are termed truncation errors. The second type of error associated with numerical computer models is roundoff error. Computer calculations are subject to a finite degree of accuracy. Thus, repeated calculation may lead to a magnification of roundoff errors. Both types of errors are usually negligible when compared to the errors associated with the initial simplification and conceptualization of the hydrogeologic system.

1.5 Results of Modeling the Existing Ground-Water Flow System

Approximately 50 simulations were performed to help evaluate the existing groundwater flow conditions before the effects of the proposed groundwater withdrawal system could be predicted. The initial simulations focused on establishing a rough calibration under equilibrium or steady state conditions; first with very simplified input, then systematically adding complexity. The criteria used for the calibration were the following:

1. the hydraulic heads observed in monitoring wells located within the drainage basin;
2. the observed groundwater flow directions in the basin including pumping wells;
3. the general topography and surface drainage;
4. surface water elevations (i.e., river, streams and lakes); and,
5. a "reasonable" groundwater recharge rate.

The hydraulic conductivity derived from the slug and pumping tests were initially considered representative of the permeability of the unconsolidated and consolidated aquifer materials throughout the drainage basin. During calibration, adjustments to the hydraulic conductivity (i.e., the addition of non-homogeneity) were necessary but only were made where deviations could be supported. The calibration process resulted in the use of a non-homogeneous aquifer to represent the existing hydraulic conditions of the unconsolidated and consolidated aquifer materials .

A uniform recharge rate of 10 inches per year was used in the model except where Laurel Run is located. A rate of 10 inches is considered reasonable because the model area is predominantly in an urban setting where buildings, paved areas, etc. reduce infiltration to the groundwater system (for Berks County an average infiltration recharge rate of 16 inches per year is reported in literature). The rate of 10 inches per year represents approximately 23 percent of the 43-inch annual average precipitation. Stream leakage was replaced by assuming that about 48 inches of water recharges as a result of Laurel Run leaking to the groundwater system. However, near the river, Laurel run was simulated as a gaining stream.

The nearby quarry, to the south of the NGK site, is inactive and was simulated as a constant head receiving water from the surrounding aquifer. It is assumed that the quarry is currently responsible for the southerly flow component that is seen towards the southern side of the NGK site. A simulation of the quarry fully filled was not used to achieve the simulated groundwater contours. It is anticipated that when the quarry is fully filled that the southerly flow component will diminish and swing to the southwest. The Schuylkill River was established as a series of constant heads that correspond to the elevation of the water level in the river.

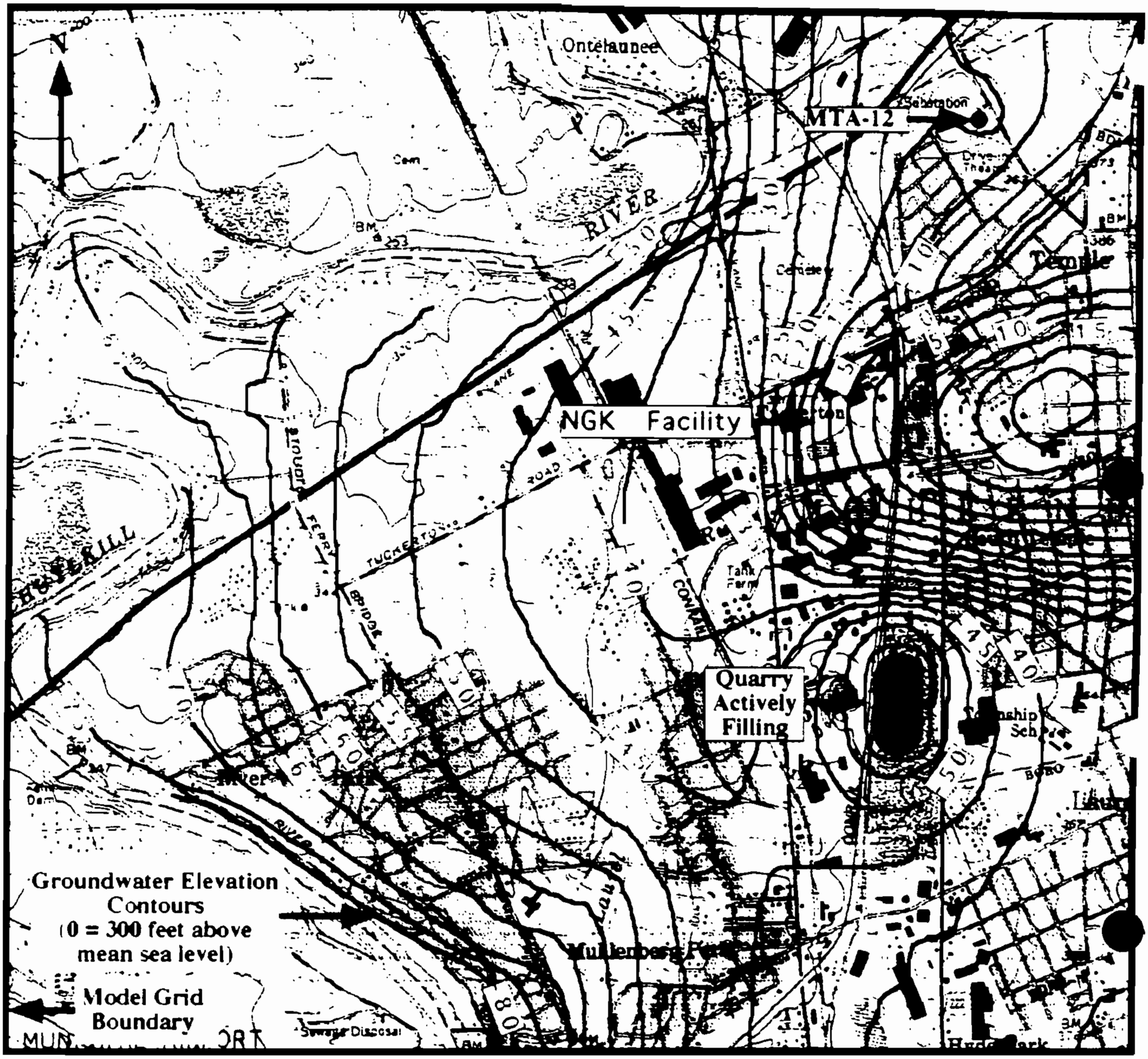
One off-site pumping well (MTA-12) north of the site was used to achieve the simulation shown in Figure 2. In part, this well is thought to be responsible for the northerly flow component seen at the northeastern side of the site. Data on water withdrawal from this well were less than precise. It is reported that the well is pumped periodically at 900 gpm. For purposes of the simulation it was assumed that this would be similar to pumping at a constant 100 gpm which is considered a reasonable assumption that does not significantly affect the on-site simulations.

The groundwater elevation map used as a template for calibration is shown in Figure 3. The simulated, static condition groundwater elevation contours for the model area are shown in Figure 2. These contours are not identical to the observed water level contours but they are a reasonable approximation to the existing conditions especially in the vicinity of the site.

As stated, numerous simulations were performed with more and more detail being added throughout the calibration process. All the details concerning calibration are not reported here. Instead, a brief overview of the numerous variables that effect the system behavior is described. These variables include the boundary condition types and their spatial distribution, the hydraulic conductivity and its spatial distribution, groundwater recharge and its spatial distribution, surface water elevations and the hydraulic conductivity of the material underlying the surface water, and fracture hydraulic conductivity.

To assess the calibration, the drawdown tests performed on wells MW-9A and MW-15A were simulated. A transient (a discrete time frame - usually not large enough to represent steady state) simulation of each drawdown test was not attempted. However, steady state was used to approximate the drawdown test simulation. An exact match to the aquifer responses observed during the drawdown test was not anticipated, however, but a satisfactory match was achieved. Shown in Figures 4 and 5 are the simulations of the drawdown test for wells MW-9A and MW-15A, respectively.

Besides the pumping test and the observed groundwater levels, there are little data quantifying the many variables used in the model. Thus, many adjustments could be made during the calibration process but such changes must be constrained within reasonable bounds appropriate for the region. It is likely that different combinations of these variables could result in the same solution. Due to the complexity of the system and the simplifications involved in the model, it was not practical with the



Scale = 2000 feet

Figure 2
Simulated Groundwater Elevation Map
(calibrated using 6/28/91 water level map shown on Figure 3)

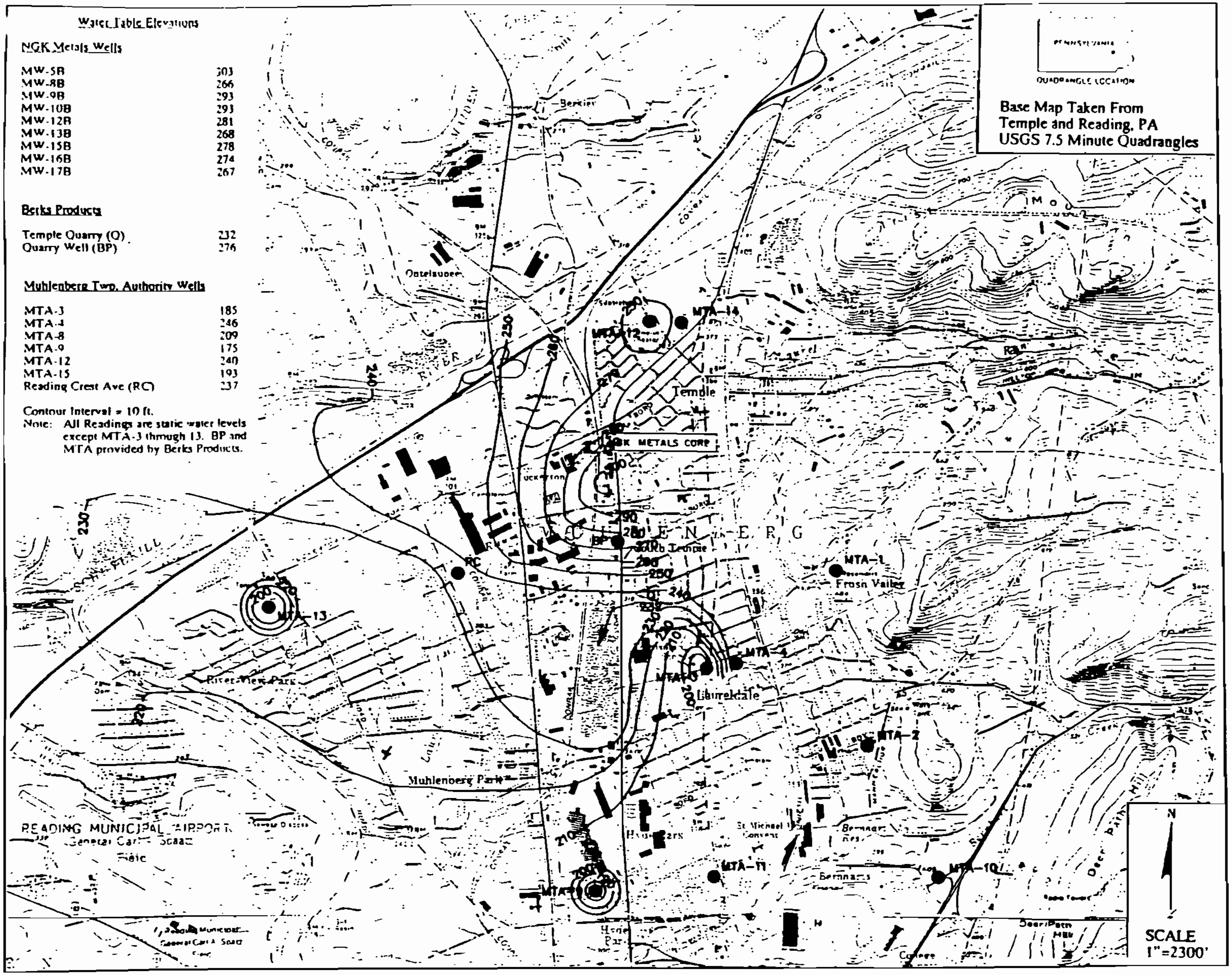


Figure 3
Regional Groundwater Elevation Map
(6/28/91)

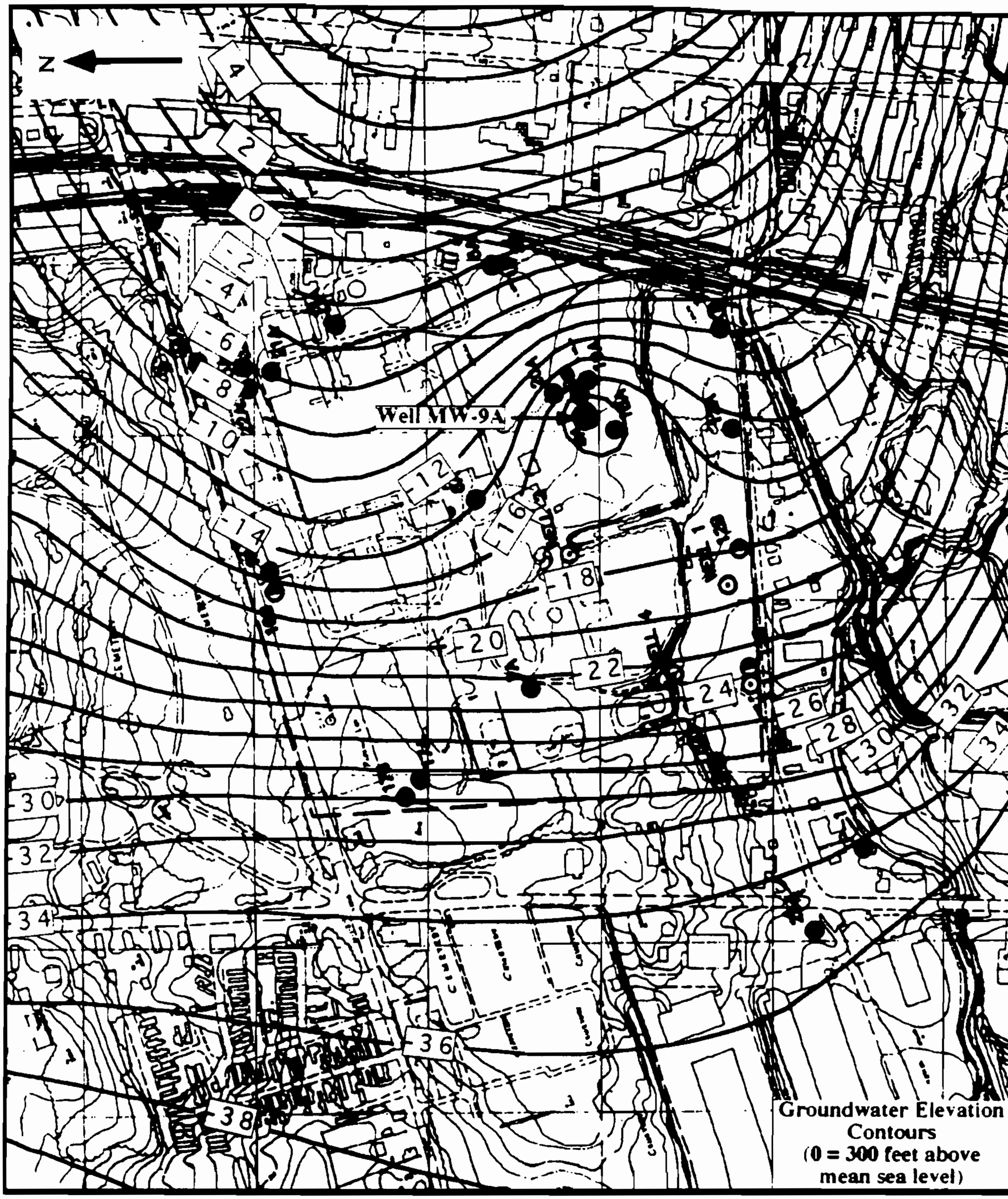


Figure 4
Simulated Groundwater Elevation Map
Well MW-9A pumping at 20 gpm
(calibrated using well MW-19A drawdown test water level data)

Scale = 400 feet

Figure 5
Simulated Groundwater Elevation Map
Well MW-15A pumping at 7 gpm
(calibrated using well MW-15A drawdown test water level data)

available data to develop a fully calibrated numerical model capable of matching the observed heads at all locations. Rather, a numerical model capable of simulating the general relationships and flow patterns was appropriate for use as a comparative tool in the groundwater withdrawal analysis.

2.0 DEWATERING ANALYSIS

2.1 General

To successfully design a groundwater withdrawal system in a complex hydrogeologic setting requires prior design considerations and refinement of design after the initial system is in place and is being monitored. For planning purposes, it is appropriate to: 1) estimate the pumpage required for the design of an effective hydraulic capture zone (pumpage estimates should reflect degree of uncertainty and consider periodic high flow conditions due to weather events); and 2) estimate the location of wells to be used in the system that will create the desired effect.

In order to make such estimations, an appropriate understanding of the hydraulic behavior of the aquifer is necessary as well as a means to calculate the quantities requiring estimation. The general hydraulic behavior of the unconsolidated and consolidated aquifer materials in the vicinity of NGK was described in prior DUNN reports. The means of quantitation for the dewatering was the numerical groundwater model previously described.

2.2 Dewatering Simulation Results

Simulation of a possible groundwater withdrawal system was performed under steady state conditions assuming 1) only the northeast side and the south and southwest sides of the site were to be considered for hydraulic capture, and 2) existing wells were used. A single groundwater withdrawal system scenario was simulated by pumping the following existing wells at the assumed rates:

MW-8A at 15 gpm;
MW-12B at 15 gpm;
MW-13B at 15 gpm;
MW-9A at 20 gpm;
MW-14A at 7 gpm;
MW-15A at 7 gpm; and
MW-16A at 7 gpm.

The simulated water level contours for the groundwater withdrawal system is shown in Figure 6. Using the assumed groundwater withdrawal rates and achieving near maximum drawdowns within the pumping wells, a zone of hydraulic capture was achieved at the south and southwest sides of the site. The wells used in the simulation produce sufficient amounts of water to allow for possible increases in pumping to acquire a complete area of capture. Therefore, the simulation of the groundwater withdrawal in this portion of the site appears feasible.

Scale = 400 feet

Figure 6
Simulated Groundwater Elevation Map
Well MW-9A pumping at 20 gpm
Well MW-8A pumping at 15 gpm
Well MW-12B pumping at 15 gpm
Well MW-13B pumping at 15 gpm
Well MW-16A pumping at 7 gpm
Well MW-15A pumping at 7 gpm
Well MW-14A pumping at 7 gpm

The wells at the northeast side of the site did not achieve a sufficient area of capture. The wells were assumed to pump at 7 gpm each which is not thought to be realistic due to the already low yield of each well at very short pumping durations. In this portion of the site the aquifer is much less productive than the southern portion of the site. Therefore, more wells will need to be drilled to provide additional pumping wells. The exact location of these wells can be anticipated. However, past experience in this area of the site indicates that most wells drilled in these locations will not produce enough water to be used in a groundwater withdrawal system. It is recommended that much more thorough thought be given to the final design of the system in this area because of the known difficulty when working at this part of the site. High traffic conditions and the fact that there is very little area that is not covered by building or parking lots may require that traffic be diverted when wells are installed and then will have to be constructed using manholes. The biggest perceived difficulty will be installing wells that produce sufficient water. Several wells may need to be drilled to get the necessary wells that will be used in the groundwater withdrawal system.

Overall, the total anticipated rate of withdrawal for the southern portion of the site is approximated at about 65 gpm. However, factors such as periods of high infiltration due to precipitation and some unknowns about the initial yield and long-term sustained yield of the wells may necessitate larger rates of withdrawal. At the northern portion of the site, it is estimated that rates of withdrawal will be around 30 to 40 gpm. Therefore, a preliminary estimate of minimum total withdrawal (for the entire site) is approximately 105 gpm.

There is some uncertainty associated with this model. Using a porous media approach suggests a hydraulic continuity which is not anticipated for a fracture dominated system. A three-dimensional approximation does not account for all vertical heterogeneity observed at the site. Lastly, because of the lack of off-site data, model simulations should not be conducted in areas of the model outside NGK's property boundaries. Overall, the model appears to function realistically on-site, considering the nature of the aquifer system.

:e.
ue
of
e.
ie
ea
;h
h
of
d
y
e
it
s

s
1
l
f
,
;

[redacted]

[redacted]

DUNN CORPORATION

Engineers, Geologists, Environmental Scientists
2 Market Plaza Way
Mechanicsburg, Pennsylvania 17055
717 795-8001
717 795-8280

RCRA CORRECTIVE MEASURES STUDY

SUMMERS MODEL

NGK METALS CORPORATION
READING FACILITY

Prepared for:

NGK METALS CORPORATION
READING FACILITY
READING, PENNSYLVANIA 19612

Prepared by:

DUNN CORPORATION
2 MARKET PLAZA WAY
MECHANICSBURG, PENNSYLVANIA 17055

Date:

FEBRUARY 21, 1992

TABLE OF CONTENTS

		PAGE
LIST OF TABLES		iii
1.0	INTRODUCTION	1-1
2.0	DESCRIPTION OF THE SUMMERS MODEL	2-1
	2.1 Estimation of a Value for the Variable Qgw	2-1
	2.2 Estimation of Qp	2-2
	2.3 Estimation of a Value for the Variable Kd	2-2
	2.4 Estimation of Values for the Variable Cs	2-3
3.0	EVALUATION OF THE SWMU'S DOWNGRADIENT FROM OTHER SWMU'S	3-1
4.0	RESULTS	4-1

LIST OF TABLES

1	Leachate Concentrations - Current Conditions	4-2
2	Leachate Concentrations - Reduction of Infiltration Amounts to Meet MCL's	4-8
3	Summary Table	4-14

1.0 INTRODUCTION

At the request of U.S. EPA Region III, the Summers Model was used to predict the concentrations of metals expected to leach from the soil and waste materials at each of the Solid Waste Management Units (SWMU) identified at the NGK facility. This model allows the use of specific analyses for metals and relate these results to the EP Toxicity results. From these actual numbers the model predicts the concentrations that can be expected to leach into the groundwater under current conditions. The various numerical values used in the Model were abstracted from the two previously prepared RCRA Facility Investigation (RFI) reports for the facility by DUNN dated November 15, 1990, and October 25, 1991.

2.0 DESCRIPTION OF THE SUMMERS MODEL

The Summers Model is a simple dilution model that predicts chemical concentrations resulting from leaching of a source and mixing of the leachate with the underlying groundwater. The model assumes that a percentage of area rainfall infiltrates the source and generates leachate by desorption of soil contaminants. The resultant chemical concentrations in the leachate are estimated on the basis that the infiltrating water will be in contact with the contaminants for a period of time sufficient for the maximum amount of leaching to occur. It is further assumed that the leachate then mixes completely with groundwater flowing under the source so that the resulting chemical concentration in the groundwater is a simple function of the leachate generation rate, the chemical concentration in the leachate, and the rate of groundwater flow under the source.

The equation that represents the Summers Model used in the assessment is:

$$C_{gw} = (Q_p \times C_p) / (Q_p + Q_{gw})$$

where: C_{gw} = Resultant chemical concentration in groundwater (µg/l)

Q_p = Volumetric flow rate of infiltration into groundwater (ft^3/day)

Q_{gw} = Volumetric flow rate of groundwater under the source (ft^3/day)

C_p = Chemical concentration in the leachate (µg/l).

A value for the variable C_p was the actual EP Toxicity results or was estimated from:

$$C_p = C_s / K_d$$

where: C_s = Chemical concentration in soil (µg/kg)

K_d = Chemical partition coefficient in soil (mg/kg per mg/l).

2.1 Estimation of a Value for the Variable Q_{gw}

In the Summers Model Q_{gw} is estimated on the basis of the application of Darcy's Law to estimate groundwater flow under the areas of concern. The Darcy equation requires the hydraulic conductivity, the hydraulic gradient, and the cross-sectional area of the aquifer under the SWMU area of the land under investigation. These values are known from the analysis of pump tests recently performed at the site.

A pump test was conducted on MW-9A (November 15, 1990) while wells MW-5A, MW-5B, MW-10A, MW-10B, MW-12A, and MW-12B were monitored for water level response. Later, other pump tests (October 25, 1991) were conducted using wells MW-19 while monitoring responses in wells MW-9A, MW-9B, MW-18, MW-20 and using well MW-15A and monitoring responses in well MW-22. These tests provided the values for hydraulic conductivity (k), hydraulic gradient (i) in some cases, and the velocity. The static water table values were used for gradient determination. The specific numbers for model variables are listed on the individual summary tables for each area (Tables 1 and 2). In areas which were not involved with the actual pump tests the hydraulic gradient was calculated based on the difference in water levels of well (Δh) divided by the distance between the wells (Δl).

2.2 Estimation of Q_p

The amount of leachate generated by a SWMU (Q_p) is the product of the surface area over which contaminated soil occurs times the annual infiltration rate. To determine the exact infiltration rate at each site, the precipitation rates were compared to the rates calculated from the falling head test results (November 15, 1990). In all but two cases the falling head values produced volumes in excess of precipitation volumes. The exact value used is indicated on the individual summary tables for each SWMU. The precipitation value of 16 inches was used (p. 5-1, November 15, 1990).

2.3 Estimation of a Value for the Variable K_d

The absorption of inorganics is influenced by clay mineralogy and water chemistry. K_d represents the value of the equilibrium partition coefficient for each inorganic compound. The values of K_d were estimated by computing the ratio of the actual soil concentration of the particular inorganic compound to the actual value from the EP Toxicity test result from the same soil interval of the same well then averaging the individual values to obtain one K_d value for each inorganic parameter.

Some inorganics were not in detectable concentrations in the TCLP tests. These concentrations may add together as water flows beneath the upgradient SWMU's to a downgradient SWMU. To check for the resultant concentrations of these low concentration of inorganics the computed K_d values were used. The following is a list of the computed K_d values for each inorganic of interest.

Average K_d Values for Inorganics

Beryllium	1,500	mg/kg
Cadmium	64	"
Chromium	4,300	"
Copper	500	"
Fluoride	112,500	"

2.4 Estimation of Values for the Variable C_S

The C_S variable represents the concentration of inorganics in the soil. Tables 7.1 and 7.2 (November 15, 1990) contain the values of a number of samples within each SMWU. However, in the Model only one value can be used. In each area the largest concentration for each inorganic in each SWMU was used regardless of depth of sample or well. The value is reported in the tables as mg/kg but the Model requires µg/kg. The conversion was obtained by multiplying each value by 1,000.

3.0 EVALUATION OF THE SWMU'S DOWNGRADIENT FROM OTHER SWMU'S

One of the assumption inherent in the Summers Model is that the background contamination concentrations are zero in the groundwater underflowing a SWMU. There are SWMU's situated with respect to the groundwater flow direction (Figure 5-5, November 15, 1990) as to impact other SWMU's.

The Retention Basin and Pond 1 are situated such that flow is to the northeast away from the other SWMU's and each other. Pond 2 is upgradient from the other SWMU's. These areas are considered individually.

For the other areas the groundwater concentration values calculated from each individual SWMU are reported individually and as a group. The calculated values were added to determine exceedence of the MCL values under the downgradient SWMU. The upgradient SWMU's were considered as an entity. No attempt was made to determine what percentage of the upgradient SWMU directly impacted the downgradient SWMU. The following is a list of the SWMU's considered as groups.

- Retention Pond
- Pond 1
- Pond 2
- Pond 3 and upgradient Pond 2
- SE Red Mud Disposal Area and upgradient Pond 2
- SW Red Mud Disposal Area and upgradient Ponds 2 and 3 and SE Red Mud Disposal Area
- Drain Field and upgradient SE Disposal Area
- Pond 6 and upgradient Ponds 2 and 3, and SW Red Mud Disposal Area

4.0 RESULTS

The results of the Summers Model and the groundwater evaluations are presented in Tables 1 and 2 which follow. Each SWMU is tested separately and grouped according to current conditions and if the infiltration rates of certain SWMU's are reduced. On each table the soil monitoring results, actual groundwater concentrations, estimated leachate concentrations calculated from the Summers Model, the comparison criteria (MCL's) and a definitive answer on whether the calculated projections made the by the Model exceed the comparison criteria. Some of the predicted values do exceed the MCL's in some SWMU's if the infiltration rate is not reduced. Table 3 compares the SWMU's under current conditions and if the amount of infiltration for some SWMU's are reduced.

The results will be used in evaluating the corrective measures to be used on the NGK property.

TABLE 1
LEACHATE CONCENTRATIONS
CURRENT CONDITIONS

SWMU: Retention Basin

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1030000	661	1432.29		
Cadmium	1000	31.8	8.51	5	YES
Chromium,total	47100	188.6	2.41	100	NO
Copper	469000	74.1	16.38	1000	NO
Fluoride	589000	5.8	1.16	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As=SWMU contaminated soil area (Square Feet)	18400
SWMU Precipitation volume (Cubic feet/yr)	24533.33
Qp=SWMU Precipitation volume (Cubic feet/day)	67.21
Ax= Cross-sectional area (square feet)	7200.00
K (ft/day)	0.47
i (ft/ft)	0.07
Qgw (clean GW flow under SWMU)(cubic feet/day)	236.88

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-15A

SWMU:Pond 1

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	8190000	19.1	7.17		
Cadmium	577000	5.2	4.92	5	NO
Chromium,total	14700000	286	137.22	100	YES
Copper	191000000	132	38.56	1000	NO
Fluoride	383000	3.1	3.07	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	32725
SWMU Precipitation volume (Cubic feet/yr)	43633.33
Qp= SWMU Precipitation volume (Cubic feet/day)	119.54
Ax= Cross-sectional flow area (square feet)	20000
K (ft/day)	0.088
i (ft/ft)	0.007467
Qgw (clean GW flow under SWMU)(cubic feet/day)	13.14

*Groundwater concentrations (filtered) from Table 6-2,10-25-91.MW-11A

TABLE 1
CONTINUED

SWMU:Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	2600000	not sampled	1195		
Cadmium	96000	not sampled	649	5	YES
Chromium,total	332000	not sampled	17	100	NO
Copper	7910000	not sampled	4616	1000	YES
Fluoride	1490000	not sampled	6	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	37700
SWMU infiltration volume (Cubic feet/yr)	32611.33
Qp= SWMU infiltration volume (Cubic feet/day)	89.35
Ax= Cross-sectional area (Square feet)	35000
K (ft/day)	4.00
i (ft/ft)	0.00
Qgw (clean GW flow under SWMU)(cubic feet/day)	100.55

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-20A

SWMU: Pond 3

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1280000	not sampled	4259.52		
Cadmium	3800	not sampled	28.52	5	YES
Chromium,total	66400	not sampled	0.24	100	NO
Copper	2550000	not sampled	696.68	1000	NO
Fluoride	1070000	not sampled	3.43	2000	NO
Total Organic Carbon	27800000	not sampled			

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	11550
SWMU Precipitation volume (Cubic feet/yr)	15400.00
Qp= SWMU Precipitation volume (Cubic feet/day)	42.19
Ax= Cross-sectional area (square feet)	26000
K (ft/day)	4
i (ft/ft)	0.00071818
Qgw (clean GW flow under SWMU)(cubic feet/day)	74.69072

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-20A

TABLE 1
CONTINUED

SWMU: Pond 6

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	678000	26.2	26.61		
Cadmium	3800		3.51	5	NO
Chromium,total	48400	350	0.66	100	NO
Copper	11900000	10.2	1402.63	1000	YES
Fluoride	267000	25	0.14	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	130100
SWMU Precipitation volume (Cubic feet/yr)	173466.67
Qp= SWMU Precipitation volume (Cubic feet/day)	475.25
Ax= Cross-sectional area (square feet)	40000
K (ft/day)	5.20
i (ft/ft)	0.04
Qgw (clean GW flow under SWMU)(cubic feet/day)	7607.39

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,Well 2

SWMU: SW Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	10900000	150	46.17		
Cadmium	639000		719.32	5	YES
Chromium,total	552000	797	7.99	100	NO
Copper	16200000		5127.44	1000	YES
Fluoride	4140000	34	2.26	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	74600
SWMU Precipitation volume (Cubic feet/yr)	99466.67
Qp= SWMU Precipitation volume (Cubic feet/day)	272.51
Ax= Cross-sectional area(square feet)	40000
K (ft/day)	5.2
i (ft/ft)	0.02
Qgw (clean GW flow under SWMU)(cubic feet/day)	4160

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-9A

TABLE 1
CONTINUED

SWMU: SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1600000	150	1004.71		
Cadmium	2900		5.88	5	YES
Chromium,total	33500	797	0.28	100	NO
Copper	16500000		599.17	1000	NO
Fluoride	1740000	34	0.56	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	52900
SWMU Precipitation volume (Cubic feet/yr)	70533.33
Qp= SWMU Precipitation volume (Cubic feet/day)	193.24
Ax= Cross-sectional area (Square feet)	49000
K (ft/day)	5.2
i (ft/ft)	0.02
Qgw (clean GW flow under SWMU)(cubic feet/day)	5096

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-9A

SWMU: Drain Field

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	945000		5.96		
Cadmium	60100		1.50	5	NO
Chromium,total	227000	396	0.09	100	NO
Copper	4910000		16.33	1000	NO
Fluoride	140000	6.1	0.01	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	16
As= SWMU contaminated soil area (Square Feet)	36100
SWMU Precipitation volume (Cubic feet/yr)	48133.33
Qp= SWMU Precipitation volume (Cubic feet/day)	131.87
Ax= Cross-sectional flow area (square feet)	33000.00
K (ft/day)	3.9
i (ft/ft)	0.25
Qgw (clean GW flow under SWMU)(cubic feet/day)	32175

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-12A

TABLE 1
CONTINUED

SWMU: Pond 3 & Upgradient Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1280000	not sampled	5454.62		
Cadmium	3800	not sampled	677.82	5	YES
Chromium,total	66400	not sampled	17.17	100	NO
Copper	2550000	not sampled	5312.40	1000	YES
Fluoride	1070000	not sampled	9.66	2000	NO

SWMU: SE Red Mud Disposal Area & Upgradient Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1600000	150	2199.81		
Cadmium	2900		655.19	5	YES
Chromium,total	33500	797	17.22	100	NO
Copper	16500000		5214.89	1000	YES
Fluoride	1740000	34	6.79	2000	NO

SWMU: SW Red Mud Disposal Area & Upgradient Ponds 2 & 3 and SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	10900000	150	6505.50		
Cadmium	639000		1403.03	5	YES
Chromium,total	552000	797	25.45	100	NO
Copper	16200000		11039.02	1000	YES
Fluoride	4140000	34	12.49	2000	NO

NOTE: Leachate totals are not exact due to rounding.

TABLE 1
CONTINUED

SWMU: Drain Field & Upgradient SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	945000		1010.67		
Cadmium	60100		7.38	5	YES
Chromium,total	227000	396	0.37	100	NO
Copper	4910000		615.50	1000	NO
Fluoride	140000	6.1	0.57	2000	NO

SWMU: Pond 6 & Upgradient Ponds 2 &3 and SW Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	678000	26.2	5527.40		
Cadmium	3800		1400.65	5	YES
Chromium,total	48400	350	25.82	100	NO
Copper	11900000	10.2	11842.47	1000	YES
Fluoride	267000	25	12.06	2000	NO

NOTE: Leachate totals are not exact due to rounding.

TABLE 2
LEACHATE CONCENTRATIONS
REDUCTION OF INFILTRATION AMOUNTS TO MEET MCL'S

SWMU: Retention Basin

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1030000	661	840.16		
Cadmium	1000	31.8	4.99	5	NO
Chromium,total	47100	188.6	1.41	100	NO
Copper	469000	74.1	9.61	1000	NO
Fluoride	589000	5.8	0.68	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	8.4
As=SWMU contaminated soil area (Square Feet)	18400
SWMU Precipitation volume (Cubic feet/yr)	12880.00
Qp=SWMU Precipitation volume (Cubic feet/day)	35.29
Ax= Cross-sectional area (square feet)	7200.00
K (ft/day)	0.47
i (ft/ft)	0.07
Qgw (clean GW flow under SWMU)(cubic feet/day)	236.88

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-15A

SWMU:Pond 1

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	8190000	19.1	5.19		
Cadmium	577000	5.2	3.56	5	NO
Chromium,total	14700000	286	99.35	100	NO
Copper	191000000	132	27.92	1000	NO
Fluoride	383000	3.1	2.22	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	3.3
As= SWMU contaminated soil area (Square Feet)	32725
SWMU Precipitation volume (Cubic feet/yr)	8999.38
Qp= SWMU Precipitation volume (Cubic feet/day)	24.66
Ax= Cross-sectional flow area (square feet)	20000
K (ft/day)	0.088
i (ft/ft)	0.007467
Qgw (clean GW flow under SWMU)(cubic feet/day)	13.14

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-11A

TABLE 2
CONTINUED

SWMU:Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	2600000	not sampled	2		
Cadmium	96000	not sampled	1	5	NO
Chromium,total	332000	not sampled	0	100	NO
Copper	7910000	not sampled	8	1000	NO
Fluoride	1490000	not sampled	0	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	0.01
As= SWMU contaminated soil area (Square Feet)	37700
SWMU infiltration volume (Cubic feet/yr)	31.42
Qp= SWMU infiltration volume (Cubic feet/day)	0.09
Ax= Cross-sectional area (Square feet)	35000
K (ft/day)	4.00
i (ft/ft)	0.00
Qgw (clean GW flow under SWMU)(cubic feet/day)	100.55

*Groundwater concentrations from Table 6-2,10-25-91,MW-20A

SWMU: Pond 3

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1280000	not sampled	41.51		
Cadmium	3800	not sampled	0.28	5	NO
Chromium,total	66400	not sampled	0.00	100	NO
Copper	2550000	not sampled	6.79	1000	NO
Fluoride	1070000	not sampled	0.03	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	0.1
As= SWMU contaminated soil area (Square Feet)	11550
SWMU Precipitation volume (Cubic feet/yr)	96.25
Qp= SWMU Precipitation volume (Cubic feet/day)	0.26
Ax= Cross-sectional area (square feet)	26000
K (ft/day)	4
i (ft/ft)	0.00
Qgw (clean GW flow under SWMU)(cubic feet/day)	74.69

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-20A

TABLE 2
CONTINUED

SWMU: SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1600000	150	32.55		
Cadmium	2900		0.19	5	NO
Chromium,total	33500	797	0.01	100	NO
Copper	16500000		19.41	1000	NO
Fluoride	1740000	34	0.02	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	0.5
As= SWMU contaminated soil area (Square Feet)	52900
SWMU Precipitation volume (Cubic feet/yr)	2204.17
Qp= SWMU Precipitation volume (Cubic feet/day)	6.04
Ax= Cross-sectional area (Square feet)	49000
K (ft/day)	5.2
i (ft/ft)	0.02
Qgw (clean GW flow under SWMU)(cubic feet/day)	5096

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-9A

SWMU: SW Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	10900000	150	0.15		
Cadmium	639000		2.39	5	NO
Chromium,total	552000	797	0.03	100	NO
Copper	16200000		17.07	1000	NO
Fluoride	4140000	34	0.01	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	0.05
As= SWMU contaminated soil area (Square Feet)	74600
SWMU Precipitation volume (Cubic feet/yr)	310.83
Qp= SWMU Precipitation volume (Cubic feet/day)	0.85
Ax= Cross-sectional area(square feet)	40000
K (ft/day)	5.2
i (ft/ft)	0.02
Qgw (clean GW flow under SWMU)(cubic feet/day)	4160

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,MW-9A

TABLE 2
CONTINUED

SWMU: Pond 6

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	678000	26.2	8.67		
Cadmium	3800		1.14	5	NO
Chromium,total	48400	350	0.21	100	NO
Copper	11900000	10.2	456.79	1000	NO
Fluoride	267000	25	0.05	2000	NO

VARIABLE VALUES	
Infiltration (inches/yr)	5
As= SWMU contaminated soil area (Square Feet)	130100
SWMU Precipitation volume (Cubic feet/yr)	54208.33
Qp= SWMU Precipitation volume (Cubic feet/day)	148.52
Ax= Cross-sectional area (square feet)	40000
K (ft/day)	5.20
i (ft/ft)	0.04
Qgw (clean GW flow under SWMU)(cubic feet/day)	7607.39

*Groundwater concentrations (filtered) from Table 6-2,10-25-91,Well 2

TABLE 2
CONTINUED

SWMU: Pond 3 & Upgradient Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1280000	not sampled	43.69		
Cadmium	3800	not sampled	1.46	5	NO
Chromium,total	66400	not sampled	0.03	100	NO
Copper	2550000	not sampled	15.18	1000	NO
Fluoride	1070000	not sampled	0.04	2000	NO

SWMU: SE Red Mud Disposal Area & Upgradient Pond 2

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	1600000	150	34.72		
Cadmium	2900		1.37	5	NO
Chromium,total	33500	797	0.04	100	NO
Copper	16500000		27.80	1000	NO
Fluoride	1740000	34	0.03	2000	NO

SWMU: SW Red Mud Disposal Area & Upgradient Ponds 2 & 3 and SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	10900000	150	76.39		
Cadmium	639000		4.04	5	NO
Chromium,total	552000	797	0.07	100	NO
Copper	16200000		51.66	1000	NO
Fluoride	4140000	34	0.07	2000	NO

NOTE: Leachate totals are not exact due to rounding.

TABLE 2
CONTINUED

SWMU: Drain Field & Upgradient SE Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	945000		38.51		
Cadmium	60100		1.69	5	NO
Chromium,total	227000	396	0.10	100	NO
Copper	4910000		35.74	1000	NO
Fluoride	140000	6.1	0.02	2000	NO

SWMU: Pond 6 & Upgradient Ponds 2 &3 and SW Red Mud Disposal Area

Parameter	Soil Monitoring Results	Actual Groundwater Concentrations*	Estimated Leachate Concentration	Comparison Criteria (MCLs)	Does the estimated Leachate Concentration exceed the Comparison Criteria?
	ug/kg	ug/l	ug/l	ug/l	
Beryllium	678000	26.2	52.51		
Cadmium	3800		5.00	5	NO
Chromium,total	48400	350	0.27	100	NO
Copper	11900000	10.2	489.04	1000	NO
Fluoride	267000	25	0.10	2000	NO

NOTE: Leachate totals are not exact due to rounding.

TABLE 3
SUMMARY TABLE

	Current Conditions			Reduction of Infiltration	
SWMU	Exceeds	Model Results	MCL/SCL	Model Results	Reduce Infiltration Amount to:
Units		ug/l	ug/l	ug/l	inches
Retention Basin	Cadmium	8.51	5	4.99	8.4
Pond 1	Chromium	137.22	100	99.35	Pond 1= 3.3
Pond 2	Cadmium	649	5	1	Pond 2= 0.01
	Copper	4616	1000	8	
Pond 3 and 2 (Upgradient)	Cadmium	677.82	5	1.46	Pond 3= 0.1
	Copper	5312.4	1000	15.18	
SE Red Mud Disposal Area and Pond 2 (Upgradient)	Cadmium	655.19	5	1.37	SE Red Mud Dis.Area= 0.5
	Copper	5214.89	1000	27.8	
SW Disposal Area and Ponds 2 &3,SE Disposal Area (Upgradient)	Cadmium	1403.03	5	4.04	SW Red Mud Dis.Area= 0.05
	Copper	11039.02	1000	51.66	
Drain Field and SE Red Mud Disposal Area (Upgradient)	Cadmium	7.38	5	1.69	Drain Field= No Change
Pond 6 and Ponds 2 & 3, SW Red Mud Disposal Area (Upgradient)	Cadmium	1400.65	5	5	Pond 6= 5
	Copper	11842.47	1000	489.04	